Importation of ‘Hass’ Avocado (*Persea americana*) Fruit from Peru into the Continental United States

United States
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Inspection
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Executive Summary

This analysis examines the risks associated with the importation of 'Hass' avocado *(Persea americana* Miller.) fruit into the United States. Among the pests found affecting avocado in Peru were nine quarantine pests (eight insects and one viroid) that may be associated with fresh avocado fruit as a pathway for introduction into the United States. These pests are as follows:

<u>Insects</u>
Acutaspis albopicta (Hemiptera: Diaspididae)
Anastrepha fraterculus Wiedemann (Diptera: Tephritidae)
Anastrepha striata (Wiedemann) (Diptera: Tephritidae)
Ceratitis capitata Wiedemann (Diptera: Tephritidae)
Coccus viridis (Green) (Hemiptera: Coccidae)
Ferrisia malvastra (McDaniel) (Hemiptera: Pseudococcidae)
Pseudaonidia trilobitiformis Green (Hemiptera: Diaspididae)
Stenoma catenifer Walsingham (Lepidoptera: Oecophoridae)

<u>Viroid</u>
Potato spindle tuber viroid

These quarantine pests are qualitatively analyzed using the methodology described in the USDA-APHIS Guidelines Ver. 5.02, which examines pest biology in the context of the Consequences of Introduction and Likelihood of Introduction, and estimates the overall Pest Risk Potential. The insects, *Acutaspis albopicta* (Hemiptera: Diaspididae), *Pseudaonidia trilobitiformis* Green (Hemiptera: Diaspididae) and *Stenoma catenifer* Walsingham (Lepidoptera: Oecophoridae) received a Medium rating for Pest Risk Potential, while all other insects were rated as High. Although the viroid was rated High in the risk assessment document, the analysis for the Likelihood of establishment of the pathogen entering on avocados for consumption estimated the probability to be Low (Appendix 2). Port-of-entry inspections are insufficient to safeguard US agriculture from pests associated with the commodity, therefore phytosanitary measures are suggested to reduce the likelihood of entry and establishment.

Table of Contents

A. Introduction

The Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) prepared this pest risk assessment to examine plant pest risks associated with the importation of fresh 'Hass' avocado, *Persea americana* fruits from Peru into the continental United States. This is a qualitative pest risk assessment. Estimates of risk are expressed in qualitative terms of high, medium, or low, rather than in numerical terms, such as probabilities or frequencies. The details of methodology and rating criteria are in the Guidelines for Pathway-Initiated Pest Risk Assessment, version 5.0 (USDA, 2000).

International plant protection organizations, such as the North American Plant Protection Organization (NAPPO) and the International Plant Protection Convention (IPPC) provide guidance for conducting pest risk analyses. The methods used to initiate, conduct, and report this pest risk assessment are consistent with the guidelines provided by NAPPO and IPPC. The use of biological and phytosanitary terms conforms to the Glossary of Phytosanitary Terms (ISPM No. 5; IPPC 2004).

Avocado is part of the Lauraceae plant family, which has about 50 genera (Ploetz *et al.*, 1994). Most members of the family have aromatic foliage and include bays, camphor, cinnamon, and sassafras. Three races of avocado are generally recognized: Mexican, West Indian and Guatemalan; these races vary in their sensitivity to cold and fruit characteristics. Hass, of the Guatemalan race, is the leading variety produced in California. Hass has the advantages of year round production and excellent storage life and fruit quality. In 1987, Peru ranked 18th in annual production of avocado with 24,000 metric tons compared to Mexico's 357,000 metrics tons (Ploetz *et al.*, 1994). Peruvian avocados for export are currently produced in Lima (20,180 Metric Tons in 1999), Ica (2,656) and Moquega (2,632) (Fig. 1, SENASA, 2002).

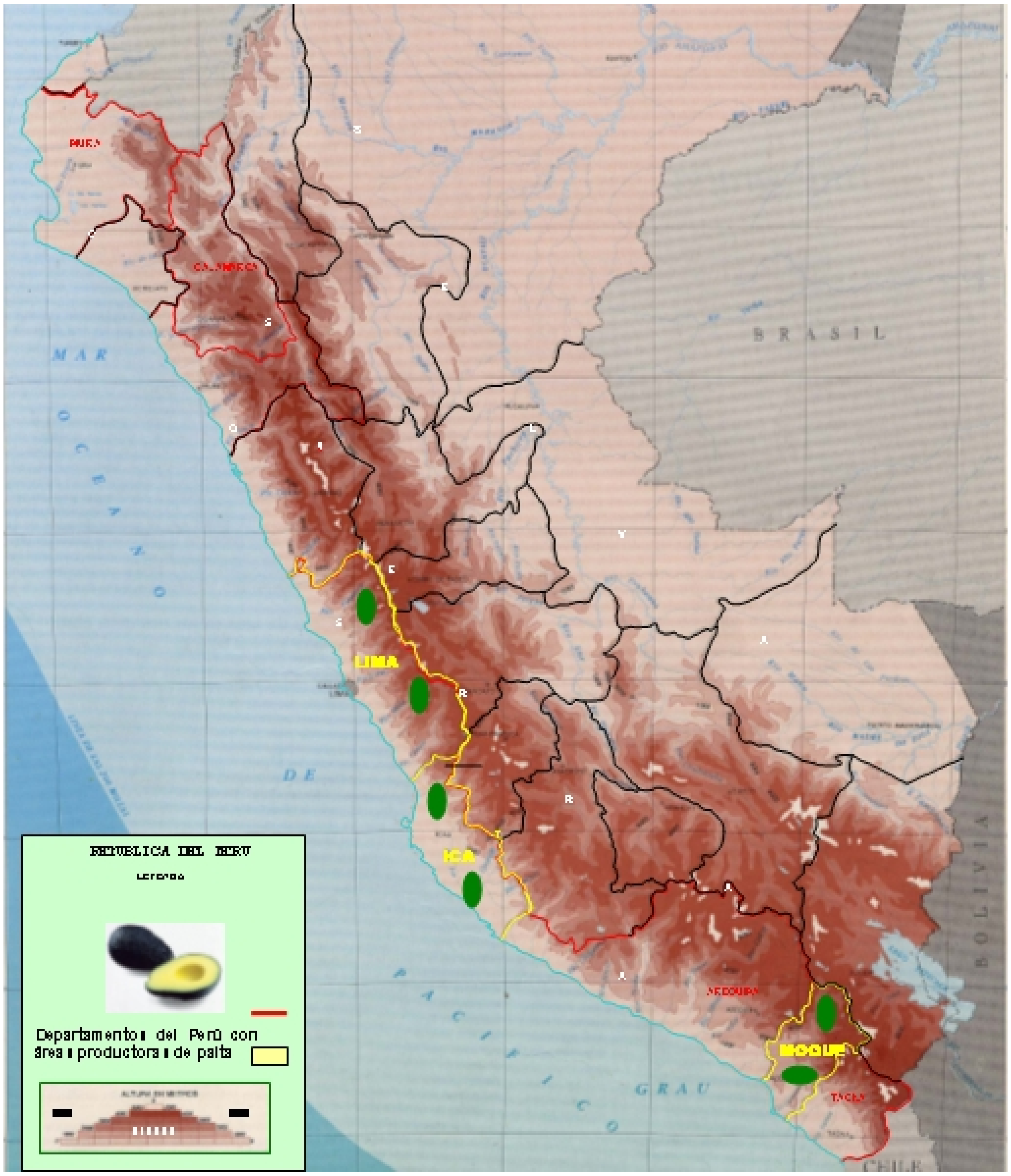

Figure 1. Avocado production in Peru (SENASA, 2002).

B. Risk Assessment

1. Initiating Event: Proposed Action

This assessment was initiated in response to an official request for USDA authorization to allow imports under 7 CFR §319.56, the regulation which provides authority to USDA for restricting or prohibiting the importation of fruits and vegetables based on the risk of introducing harmful exotic plant pests into the United States. The PRA request was made by G.A. Ball, Import Specialist, Riverdale, MD, on October 31, 2001. The importation of "Hass' avocado (*Persea americana)* from Peru into the United States is a potential pathway for the introduction of pests. This pest risk assessment is commodity-based and therefore pathway-initiated.

History of Relevant Correspondence with Peru

- December 29, 2000. Facsimile (2725) from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter included a request to export *Persea americana* fruit to the United States and contained the enclosed document "The Phytosanitary Status of the avocado (*Persea americana* Miller) in Peru."

- January, 11, 2002. Facsimile from Robert V. Flanders, Risk Assessment Branch Chief, APHIS to Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter indicated that APHIS has a backlog of PRAs. SENASA was offered the chance to conduct the PRA as a way to expedite the risk assessment process.

- January, 14, 2002. Letter from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter indicated that Annabella Reszcynski was compiling information regarding the cultivation of Avocado in Peru.

- March 27, 2002. Letter from Alan S. Green (USDA/APHIS) to Drab. Elsa Carbonell Tores, SENASA. The letter acknowledged receipt of the report "The Phytosanitary Status of the avocado (*Persea americana* Miller) in Peru." The letter requested additional information relating to the harvest, packaging, shipment and export of avocados from Peru.

- June 14, 2002. Letter (1653-2002-AG-SENASA-DGSV-DDF) from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter listed helpful reference material for the PRA process.

- July 11, 2002. Letter (1867-2002-AG-SENASA-DGSV-DDF) from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter provided the additional information requested by Alan S. Green on March, 27 2002.

- June 17, 2003. Letter from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter indicated that only the "Hass" variety of avocado should be considered for export.

Documents Supplied by Peru

1. "The Phytosanitary Status of the avocado (*Persea americana* Miller) in Peru." December, 2002. DGSV-DVF/DDF, 12 pp.

2. Untitled document describing additional information to continue the PRA for fresh avocado destined for the US, July 2002.

3. Draft proposal for the application of pest risk mitigation measures in the exportation of avocado (*Persea americana*) to the United States from Peruvian sites where the avocado seed moth (*Stenoma catenifer*) is not known to occur. SENASA, August, 2002.

4. "Importation of avocado fruit (*Persea Americana*) from Peru. A Pest Risk Assessment." SENASA, Dec 2002.

2. Assessment of Weediness Potential of *Persea americana* (avocado).

Table 1: Weediness Potential of *Persea americana*.
Phase 1: Persea americana is widely cultivated in California and Florida (Ploetz et al., 1994; USDA, 2003b). Phase 2: Is the species listed in: NO *Geographical Atlas of World Weeds* (Holm *et. al.,* 1979) NO *World's Worst Weeds* (Holm *et. al.*, 1977) or *World Weeds: Natural Histories and Distribution* (Holm *et al.*, 1997) NO *Report of the Technical Committee to Evaluate Noxious Weeds; Exotic Weeds for Federal Noxious Weed Act* (Gunn & Ritchie, 1982) NO *Economically Important Foreign Weeds* (Reed, 1977) NO Weed Science Society of America list (WSSA, 1989) NO Is there any literature reference indicating weediness (*e.g.*, *AGRICOLA, CAB, Biological Abstracts, AGRIS*; search on "species name" combined with "weed"). Phase 3: Conclusion: *Persea americana* is not considered to be an economically important weed.

3. Previous Risk Assessments, Current Status, and Pest Interceptions

PPQ's Decision History for avocado *(Persea americana)* fruit (limited to the last 30 years for South America) included one record: 1969 - Peru, avocado: Entry was denied for lack of effective treatments for *Ceratitis capitata*, *Anastrepha fraterculus*, *A. serpentina* and *Stenoma catenifer*.

Avocado importation requests from other South American countries were denied in the following years due to lack of effective treatments for *S. catenifer* and/or *Anastrepha* sp.:

1961 - Columbia
1970 - Columbia
1974 - Brazil, Columbia
1977 - Chile
1991 - Argentina
1994 - Eucador

USDA does not currently authorize the importation of avocado from South America except for from Chile (PPQ, 2004). Importation of avocado from Peru is currently not authorized. A list of pest interceptions on avocado from Peru is shown in Table 2. A list of pest interceptions for selected South American countries is found in Appendix 1.

Table 2. Pest Interception Data for *Persea americana* (avocado) fruit from Peru, 1985-Present (March, 2002): Total number of interceptions

PEST	Total number of interceptions
Anastrepha sp. (Tephritidae)	1
Cladosporium sp.	1
Curculionidae, species of	1
Diaspididae, species of	1
Heilipus sp. (Curculionidae)	1
Oecophoridae, species of	2
Pentatomidae, species of	1
Phomopsis sp.	1
Pseudaonidia trilobitiformis (Diaspididae)	10
Pseudococcidae, species of	3
Sphaceloma sp.	1
Stenoma catenifer (Oecophoridae)	8
Total	**31**

4. Pest List: Pests Associated with *Persea Americana* in Peru

Table 3 lists the pests found associated with *Persea americana*. The table was compiled from scientific and regulatory reports, including pest lists provided by Peruvian officials. Information sources consulted included bibliographic databases, such as AGRICOLA and CAB Abstracts; CAB International Crop Pest Compendium (CABI, 2002); previous risk assessments relevant to the proposed commodity; PPQ's Catalog of Intercepted Pests and interception records [USDA Port Information Network (PIN) 309 Database]; Commonwealth Institute of Entomology (CIE) and Commonwealth Mycology Institute (CMI) Distribution Maps and/or Descriptions of plant pests; PPQ data sheets on Pests Not Known to Occur in the United States (PNKTO) and Insects Not Known to Occur in the United States (INKTO); standard texts; and published and unpublished scientific and regulatory reports. For each pest, Table 3 summarizes information on the presence or absence in the United States, commodity association (*i.e.*, the generally attacked/infected plant parts), quarantine status in the United States, and the likelihood that the pest could move with the commodity in commerce (*i.e.* follow the pathway). [Note: Fungal taxonomy is referenced to Kirk *et al.* (2001).]

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	Distribution[1]	Plant Part Affected[2]	Quarantine Pest[3]	Likely to Follow Pathway[4]	References
ARTHROPODS					
ACARI					
Tarsonemidae					
Polyphagotarsonemus latus Banks	PE, US	L, S, F, FL	N	Y	CABI, 2002
Tetranychidae					
Oligonychus mangiferus (Rahman and Sapra)	PE	L	Y	N	Bolland *et al.*, 1998; Hill, 1983
Oligonychus peruvianus (McGregor)	PE, US	L	N	N	Bolland *et al.*, 1998; CABI, 2003
Oligonychus punicae (Hirst)	PE, US	L	N	N	Bolland *et al.*, 1998; Hofshi, 2005
Oligonychus yothersi (McGregor)	PE, US	L	N	N	Bolland *et al.*, 1998
Panonychus citrii (McGregor)	PE, US	L	N	N	Bolland *et al.*, 1998; Wysoki *et al.*, 2002
Tetranychus mexicanus (McGregor)	PE, US	L	N	N	Bolland *et al.*, 1998
Tetranychus neocaledonicus André	PE, US	L	N	N	Bolland *et al.*, 1998
Tetranychus sp.	PE	L	Y	N	Alata Condor, 1973
Tetranychus urticae Koch	PE, US	L	N	N	Bolland *et al.*, 1998

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Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
INSECTA					
COLEOPTERA					
Bruchidae					
Acanthoscelides sp.	PE, US	Sd	Y	N	Adame, 1998; EMLU, 2003
Cerambycidae					
Derobrachus asperatus Bates	PE	S	Y	N	Alata Condor, 1973
Oncideres poecilla Bates	PE	S	Y	N	Alata Condor, 1973; Wysocki *et al.*, 2002
Oncideres sp.	PE, US	S	Y	N	Alata Condor, 1973; CABI, 2003
Curculionoidae					
Copturomimus sp. L.	PE	S (branches)	Y	N	Alata Condor, 1973; Wysoki *et al.*, 2002;
Heilipus empiricus (Pascoe)	PE	F[5], S[5]	Y	N[5a]	Alata Condor, 1973; Wysoki *et al.*, 2002
Heilipus sp.	PE	F, Sd	Y	N[5b]	PIN 309, 2005
Pantomorus cervinus Boheman	PE, US	L, F, S, R	N	Y	CABI, 2002
Rhynchophorus palmarum L.	PE	R, S	[Y]	N	CABI, 2002
Languriidae					
Toramus sp.	PE, US	Sd, Pd	N[14]	N	Alata Condor, 1973
Histeridae					
Acritus sp.	PE, US	U	N[14]	U	Alata Condor,

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Scientific Name, Classification	Distribution[1]	Plant Part Affected[2]	Quarantine Pest[3]	Likely to Follow Pathway[4]	References
					1973
Nitulidae					
Carpophilus sp.	PE, US	F	N[14]	Y	Alata Condor, 1973
Scolytidae					
Pagiocerus frontalis Fabricus	PE, US	S	N	N	Alata Condor, 1973
DIPTERA					
Agromyzidae					
Liriomyza trifolii Burgess in Comstock	PE, US	L	N	N	CABI, 2003; IHS, 1999
Cecidomyiidae					
Clinodiplosis sp.	PE, US	Flw, Sd, L	N[14]	N	Alata Condor, 1973
Lonchaeidae					
Neosilba pendula	PE	S, F	Y	N[15]	Hofshi, 2005
Silba sp.	PE	S, F	Y[6]	N[15]	Alata Condor, 1973; CABI, 2002; Katsoyannos, 1983
Muscidae					
Atherigona orientalis Schiner	PE US (CA, TX, GA, FL, HI)	L, S, F	N	Y	CABI, 2002
Tephritidae					
Anastrepha fraterculus Wiedemann	PE	F	Y	Y	CABI, 2002; Norrbom 2004; Ovurski et al., 2003; White

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					and Elson-Harris, 1992
Anastrepha obliqua (Macquart)	PE	F	Y	N[16b]	CABI, 2004; Norrbom, 2004
Anastrepha serpentina (Wiedemann)	PE	F	Y	N[16a]	Bush, 1957; CABI, 2002
Anastrepha striata Schiner	PE	F	Y	Y	Ballou, 1936; CABI, 2002; Jiron *et al.*, 1988; White & Elson-Harris, 1992
Ceratitis capitata Wiedemann	PE, US (HI)	F	Y	Y	CABI, 2002; Liquido et al., 1998; Metcalf & Metcalf, 1993; White & Elson-Harris, 1992
Xanthaciura major Malloch	PE, US	Flw[7]	N	N	Alata Condor, 1973; Morin *et al.*, 1997; Peña and Bennett, 1995

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Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
HEMIPTERA					
Aetalionidae					
Aetalion reticulatum L.	PE	F, S, Flw, L	Y	N[18]	Alata Condor, 1973; Briceno, 1977, Dominguez Gil, 1983
Aleyrodidae					
Aleurodicus cocois Curtis	PE	L	Y	N	Lopez and Kairo, 1999; Silva, 1978
Aleurodicus dispersus Russell	PE, US (FL, HI)	L	[Y[19]]	N	CABI, 2003
Aleurodicus pulvinatus (= *A. ridescens*)	PE	L	Y	N	CABI, 2003
Aphididae					
Aphis gossypii (Glover)	PE, US	L, S, Flw	N	N	Blackman & Eastop, 1984; CABI, 2003
Aphis spiraecola Patch	PE, US	L, S, Flw	N	N	CABI, 2003
Myzus persicae Sulzer	PE, US	L, S	N	N	CABI, 2002
Toxoptera aurantii Boyer de Fonscolombe	PE, US	L, S, Flw	N	N	Blackman and Eastop, 2000; CABI, 2003
Coccidae					
Ceroplastes cirripediformis Comstock	PE, US	L, S	N	N	Ebeling, 1959; USDA, 2003a
Ceroplastes floridensis Comstock	PE, US	L, S[20]	N	N	Ebeling, 1959; USDA, 2003

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Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
Coccus hesperidum (L)	PE, US	L, S	N	N	CABI, 2003; USDA, 2003
Coccus viridis (Green)	PE, US (FL, HI)	L, S, F	[Y][8]	Y	CABI, 2003, USDA, 2003
Parasaissetia nigra Nietner	PE, US	L, S	N	N	CABI, 2002
Parthenolecanium corni (Bouché)	PE, US	L, S	N	N	CABI, 2002; Swirski *et al*., 1997
Protopulvinaria pyriformis Cockerell	PE, US (FL)	L, F, S	N	Y	Alata Condor, 1973; Ebeling, 1959; Wolfe, *et al.* 1969; Wysoki *et al.*, 2002
Saissetia coffeae Walker	PE, US	L, S	N	N	CABI, 2002
Saissetia oleae Oliver	PE, US	L, S	N	N	CABI, 2002
Diaspididae					
Acutaspis sp.	PE, US	L, S, F	Y	Y	Alata Condor, 1973; Peña *et al*., 2003
Acutaspis albopicta (Cockerell)	PE, US (TX, CA)	L, F	[Y]	Y	USDA, 2003a
Acutaspis subnigra McKenzie	PE	L	Y	N	USDA, 2003a
Aspidiotus destructor	PE, US (CA, FL)	L, F	N	Y	CABI, 2002
Chrysomphalus aonidum (L.)	PE, US	L, S, F	N	Y	
Chrysomphalus dictyospermi Morgan	PE, US	L, S, F	N	Y	CABI, 2003

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Fiorinia fioriniae Targ.	PE, US	L, F	N	Y	Alata Condor, 1973; Wysoki *et al*., 2002
Hemiberlesia cyanophyilli Signoret [Syn. *Abgrallaspis cyanophylli* (Signoret)]	PE, US	L, S, F[9]	N	Y	Alata Condor, 1973; CABI, 2003
Hemiberlesia lataniae Signoret	PE, US	L, S, F	N	Y	CABI, 2002; Nakahara, 1982
Hemiberlesia palmae (Cockerell)	PE, US (CA, FL)	L	N	N	USDA, 2003a
Hemiberlesia rapax (Comstock)	PE, US	L, S, F	N	Y	CABI, 2003; UCIPM, 2003
Howardia biclavis (Comstock)	PE, US	U	N	U	USDA, 2003a
Lopholeucaspis cockerelli (Grandpré & Charmoy)	PE, US	U	N	U	USDA, 2003a
Oceanaspidiotus spinosus (Comstock)	PE, US	L, Bark	N	N	USDA, 2003a
Pinnaspis aspidistrae (Signoret)	PE, US	S, L, F	N	Y	SENASA, 2003; USDA, 2003a
Pinnaspis sp.	PE, US	S, L, F	Y	Y	PIN 309, 2003
Pinnaspis strachani (Cooley)	PE, US	S, L, F	N	Y	USDA, 2003a
Pseudaonidia trilobitiformis Green	PE, US (FL)	F[21], L	[Y][22]	Y	Anon., 1979; Coile and Dixon, 2000; PIN 309
Selenaspidus articulatus Morgan	PE, US (CA)	L, S, F	N	Y	CABI, 2002, Wysoki *et al.*,

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					2002
Unaspis citri Comstock	PE, US	L, F	N	Y	Alata Condor, 1973; USDA, 2003; Wysoki *et al*., 2002
Margarodidae					
Icerya purchasi Maskell	PE, US	L, S	N	N	CABI, 2003; Mendel *et al*., 1992
Membracidae					
Tylopelta sp.	PE	S[25]	Y[6]	N	Alata Condor, 1973
Pentatomidae					
Pentatomidae, species of	PE, US	L, F	Y[6]	N[23]	PIN 309, 2003
Pseudococcidae					
Dysmicoccus brevipes Cockerell	PE. US	L, S, R, F	N	Y	CABI, 2003
Ferrisia malvastra (McDaniel)	PE, US (AZ)	L, F, S[10]	[Y]	Y	Gullan *et al*., 2003; USDA, 2003
Ferrisia virgata Cock	PE, US	L, F, S	N	Y	CABI, 2003
Nipaecoccus nipae Maskell	PE, US	L, S, F	N	Y	CABI, 2003
Planococcus citri (Risso)	PE, US	L, S, F, R	N	Y	CABI, 2003;
Pseudococcus longispinus Targioni	PE, US	S, F, L	N	Y	CABI, 2002
Triozidae					
Trioza perseae Tuthill	PE	L	Y	N	Alata Condor, 1973; Chavez *et al*., 1985; Hollis and Martin, 1997

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HYMENOPTERA					
Formicidae					
Acromyrmex hispidus Santaschi	PE	L	Y	N	Alata Condor, 1973; San Juan, 2003
Atta cephalotes L.	PE	L	Y	N	Alata Condor, 1973; CABI, 2003
Atta sexdens (L.)	PE	L	Y	N	Ebeling, 1959
LEPIDOPTERA					
Geometridae					
Sabulodes caberata Gueneé	PE, US (CA)	L	N	N	Alata Condor, 1973; Condit, 1915; THCD, 2003; Wysocki *et al.*, 2002
Gracilariidae					
Phyllocnistis n. sp.	PE	L	Y	N	CABI, 2002, Wysocki *et al.*, 2002
Lymantriidae					
Eloria sp.	PE	L, S	Y	N	Alata Condor, 1973; U.S. Congress, 1993
Noctuidae					
Chrysodeixis includens (Walker) [Syn. Pseudoplusia includens (Walker)]	PE, US	L, F, Flw	N	N[11]	CABI, 2003
Helicoverpa zea (Boddie)	PE, US	L, I, F, Sd	N	Y	CABI, 2003; Robinson *et al,*

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					2004
Peridroma saucia Hübner	PE, US	L, S, F, Flw	N	N[11]	CABI, 2002
Spodoptera eridania Stoll	PE, US	L, F	N	N[11]	CABI, 2002
Oecophoridae					
Stenoma catenifer Walsingham	PE, US (HI)[32]	L, F	Y	Y	Alata Condor, 1973, CABI, 2002; Ebeling, 1959; Wysoki *et al.*, 2002
Pyralidae					
Jocara zetila Druce	PE	L	Y	N	Alata Condor, 1973; Arellano Cruz, 1998
Stericta albifasciata (Druce) [Syn. *Jocara ban* Dyar]	PE	L	Y	N	CABI, 2002; Ebeling, 1959 Zhang, 1994
Psychidae					
Oiketicus kirbyi Guilding	PE	L	Y	N	Alata Condor, 1973; Arce *et al.*, 1987; Ponce *et al.*, 1981; Rhainds *et al.*, 1996
Sesiidae					
Aegeria sp.	PE, US	S (trunk)[24]	Y	N	Alata Condor, 1973; BFW, 2004; Zhang, 1994
Tortricidae					
Platynota sp.	PE, US	L	Y	N	Alata Condor,

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					1973
THYSANOPTERA					
Thripidae					
Heliothrips haemorrhoidalis Bouche	PE, US	L, F	N	Y	CABI, 2002
Selenothrips rubrocinctus Giard	PE, US	L, F	N	Y	CABI, 2002
Viruses					
Avocado sunblotch viroid	PE US (CA FL)	L, F, S, FL	N	Y	Ploetz, *et al.*, 1994, Vargas, *et al.* 1991
Potato spindle tuber viroid	PE	L, F, S, FL	Y[29]	Y	CABI 2003; Querci, *et al.* 1995
Bacteria					
Cephaleuros viriscens Künze	PE	L, S	Y	N	CABI 2003; Bazán de Segura, 1959

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution**[1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**[4]	**References**
Rhizobium radiobacter (Beijerinck & van Delden 1902) Young (Rhizobiaceae, Rhizobiales)	PE, US	R, S	N	N	CABI, 2002
Fungi					
Acrothecium lunatum Wakker (=*Curvularia lunata* (Wakk.) Boedijn) (Anamorphic Ascomycetes)	PE, US	L	N	N	CABI 2003; Wellman, 1977
Armillaria mellea (Vahl) P. Kumm. (Agaricales, Marasmiaceae*)*	PE, US	L, R, S	N	N	CABI 2003; Gonzales and Abad, 1975; Wellman, 1977
Aspergillus niger Tiegh. (Anamorphic, Trichocomaceae)	PE, US	F, L, R, S, FL	N	Y	CABI 2003; Torres and Gamarra, 1988; Wellman, 1977
Botryodiplodia sp. *(*Anamorphic Ascomycetes*)*	PE, US	F, FL, L, S	N	Y	Farr *et al*., 2004; Torres and Gamarra, 1988

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution**[1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**[4]	**References**
Botryosphaeria dothidea (Moug.) Ces. & de Not. *{= Physalospora perseae Doidge}* (Dothiodales, Botryosphaeriaceae)	PE, US	F[13], L[13], S[13]	N	Y	Bazán de Segura, 1959; CABI 2003; Farr *et al*., 2004, Kirk, et al. , 2001; Ploetz et al., 2003.
Botrytis cinerea Pers.: Fr (Anamorphic Helotiales, Sclerotiniaceae)	PE, US	L, S, FL, F, Sd	N	Y	CABI 2003; Wellman, 1977
Ceratocystis fimbriata Ellis & Halst (Microascales, Ceratocystidaceae)	PE, US	F, L, R, S	N	Y	CABI 2003; Farr *et al*., 2004;
Cercospora lingue Speg. (Anamorphic Mycosphaerellales, Mycosphaerellaceae)	PE	L, F	N[12]	Y	Farr *et al*., 2004; Wellman, 1977
Cercospora perseae[28] Ell. & Mart. (Anamorphic Mycosphaerellales, Mycosphaerellaceae)	PE, US (FL)	L, F	N	Y	Farr *et al*., 2004; Wellman, 1977 Palm, pers. com. 2005
Cercospora purpure[28]*a* (Cooke) Deighton (= Pseudocercospora purpurea (Cooke) Deighton) (Anamorphic Mycosphaerellales, Mycosphaerellaceae)	PE, US	F, L	N[33]	Y	Bazán de Segura, 1959; CABI 2003; Farr *et al*., 2004; Ploetz *et al.* 1994; Wellman, 1977

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
Cladosporium sp. (Anamorphic Mycosphaerellales, Mycosphaerellaceae,*)*	PE, US	R, S, F	Y[6]	Y	CABI, 2003; PIN 309, 2003
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. in Penz. Teleomorph: *Glomerella cingulata* (Stone.) Spauld. & H. Schrenk (Anamorphic Incertae sedis, Glomerellaceae)	PE, US	F, FL, L, S	N	Y	CABI, 2002; Ploetz, *et al.*, 1994
Corticium salmonicolor Berk. & Broome (Polyporales, Phanerochaetaceae)	PE, US	L, S	N	N	CABI 2003; Farr *et al*., 2004; Wellman, 1977
Fusarium lateritium Nees (Anamorphic Hypocreales, Nectriaceae)	PE, US	F, R, S, FL,	N	Y	CABI 2003; Icochea *et al.*, 1994; Wellman, 1977
Fusarium roseum Link (Anamorphic Hypocreales, Nectriaceae)	PE, US	F, R, S, L	N	Y	CABI 2003; Icochea *et al.*, 1994; Wellman, 1977
Fusarium oxysporum Schlecht (Anamorphic Hypocreales, Nectriaceae)	PE, US	F, R, S, L	N	Y	CABI 2003; Icochea *et al.*, 1994; Wellman, 1977
Fusarium solani (Martius) Sacc. (*Nectria haematococca* (Wollenw.) Gerlach	PE, US	S, R	N	N	CABI 2003; Farr *et al.*, 2004

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
[teleomorph]) (Anamorphic Hypocreales, Nectriaceae)					
Gibberella avenacea R.J. Cook (Nectriaceae, Hypocreales)	PE, US	F, FL, L, S	N	Y	CABI, 2002
Glomerella cingulata (Stonem.) Spauld. & Schrenk (Incertae sedis, Glomerellaceae)	PE, US	F, L, S, FL, Sd	N	Y	CABI 2003; Farr *et al*., 2004
Lasiodiplodia theobromae (Pat.) Griffiths & Maubl. [anamorph] (*Physalospora rhodina* Berk. & M.A. Curtis [teleomorph]) (Xylariales; Hyponectriaceae:)	PE, US (CA, FL, GA)	F, FL, L, S	N	Y	CABI 2003; Bazán de Segura, 1959
Macrophomina phaseolina (Tassi) Goid (Anamorphic Ascomycetes)	PE, US	F, FL, L, R, S, Sd	N	Y	CABI 2003; Farr *et al*., 2004
Mucor sp. (Mucorales, Mucoraceae)	PE, US	L, F	N	Y	Arce *et al*., 1974; Wellman, 1977
Mycena citricolor (Berk. and Curtis) Sacc. (Agaricales, Tricholomataceae)	PE, US (FL)	L, F, S	N[26]	N[27]	CABI, 2002; Wellman, 1977

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
Nectria rigidiuscula Berk. & Broome (Hypocreales, Nectriaceae)	PE, US	S, F	N	Y	CABI, 2002
Nigrospora oryzae Huds. (Anamorphic Trichosphaeriales, Incertae sedis)	PE, US	L, F	N	Y	CABI, 2002; Vallejos and Mattos, 1990; Wellman, 1977
Oidium sp. (powdery mildew) (Anamorphic Erysiphales, Erysiphaceae)	PE, US (FL)	L	N[6]	N	Alfieri, 1984; Bazán de Segura, 1959; Pernezny, 2000
Pellicularia koleroga Cooke (= *Corticium koleroga* (Cooke) Hцhnel) (Anamorphic Ceratobasidiales, Ceratobasidiaceae)	PE, US (FL)	S, L	N	N	CABI, 2002; Wellman, 1977
Pestalotia guepini Desm. (Anamorphic Xylariales, Amphisphaeriaceae)	PE, US (FL)	L, F	N	N	Alfieri, 1984; Bazán de Segura, 1959
Pestalotia leprogena Speg. (Anamorphic Xylariales, Amphisphaeriaceae)	PE, US (HI)	L	N	N	Farr *et al.*, 2004; Wellman, 1977
Pestalotia neglecta Th. (Anamorphic Xylariales, Amphisphaeriaceae)	PE, US	L, S, F	N	Y	Farr *et al.*, 2004; Wellman, 1977
Phomopsis sp. (Anamorphic Diaporthales, Valsaceae)	PE, US (FL)	F, S	Y[6]	Y	Alfieri, 1984; PIN 309, 2003
Phytophthora cactorum (Lebert & Cohn) Schröter	PE, US	L, S, F, R	N	Y	CABI, 2003

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
(Pythiales, Pythiaceae)					
Phytophthora cinnamomi Rands (Pythiales, Pythiaceae)	PE, US	L, S, R	N	N	Bazán de Segura, 1959; CABI, 2002; Ploetz, *et al.*, 1994
Phytophthora citrophthora (R.H. Sm. & E. Sm.) Leonian (Pythiales, Pythiaceae)	PE, US	F, L, R, S, Sd	N	Y	CABI, 2003; Farr *et al.*, 2004
Phytophthora nicotianae Breda de Haan var. *parasitica* (Dastur) G.M. Waterhouse (Pythiales, Pythiaceae)	PE, US	L, S, F, R	N	Y	Alfieri, *et al.*, 1984; Farr, *et al.*, 1989; CMI, 1964; CABI, 2003
Phytophthora palmivora (E. J. Butler) E. J. Butler (Pythiales, Pythiaceae)	PE, US	L, S, F, R, FL	N	Y	CABI, 2003; Wellman, 1977
Polyporus hirsutus (Wulfen:Fr.)Fr. (Polyporales, Polyporaceae)	PE, US	S	N	N	Farr *et al.*, 2004; Wellman, 1977
Polyporus sanguineus (L.:Fr.) Murrill (Polyporales, Polyporaceae)	PE, US	S	N	N	Farr *et al.*, 2004; Renjifo and Trujillo, 1992
Pythium ultimum Trow (Pythiales, Pythiaceae)	PE, US	R	N	N	CABI, 2003; Perez *et al.*, 1994; Wellman, 1977
Rhizoctonia solani K#uhn (*Thanatephorus cucumeris* (Frank) Donk [teleomorph])	PE, US	L, S, F, R, FL, Sd	N	Y	CABI, 2003; Farr *et al.*, 2004;

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
(Anamorphic Ceratobasidiales, Ceratobasidiaceae)					Wellman, 1977
Rhizoctonia sp. (Anamorphic Ceratobasidiales, Ceratobasidiaceae)	PE, US	L, S, F, R, FL, Sd	N	Y	Perez, 1999; Wellman, 1977
Rigidoporus microporus (Sw.:Fr.) Overeem (Polyporales, Meripilaceae)	PE, US	R, S	N	N	CABI, 2003; Farr *et al*., 2004
Rosellinia bunodes (Berk. & Br.) Sacc. Black (Rosellinia) (Polyporales, Meripilaceae)	PE	R, S	Y	N	Menge and Ploetz, 2003; Ploetz, *et al.*, 1994; Watson, 1971; CMI, 1985, CABI 2003; Farr *et al*., 2004
Sclerotinia sclerotiorum (Lib.) de Bary (Helotiales, Sclerotiniaceae)	PE, US	L, S, F, FL, R	N	Y	CABI, 2002
Sclerotium rolfsii Sacc. (Anamorphic Polyporales, Atheliaceae)	PE, US	L, S, F, R, FL, Sd	N	Y	CABI, 2003; Wellman, 1977

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
Sphaceloma perseae Jenk. (Anamorphic Myriangiales, Elsinoaceae)	PE, US (FL, TX)	F, FL, L	N	Y	Alfieri, *et al.*, 1984; CABI, 2002; Farr *et al.*, 2004; Pernexny, 2000.
Sphaeropsis tumefaciens Hedges (Anamorphic Actinomycetes)	PE, US (FL)	S	N[31]	N	CABI, 2003; Timmer, 2003
Verticillium dahliae Kleb. (Anamorphic Hypocreales, Hypocreaceae)	PE, US	L, S, F, R, FL, Sd	N	Y	CABI, 2003; Farr *et al.*, 2004;
NEMATODES					
TYLENCHIDA					
Belonolaimidae					
Tylenchorhynchus sp.	PE, US	R	Y	N	Torres, 1977; Wellman, 1977
Hoplolaimidae					
Criconemoides sp.	PE, US	R	N	N	CABI 2003; Wellman, 1977
Helicotylenchus dihystera (Cobb) Sher	PE, US	R	N	N	CABI, 2003
Helicotylenchus multicinctus (Cobb) Golden	PE, US	R	N	N	CABI, 2003
Helicotylenchus sp.	PE, US	R	Y	N	Torres, 1977; Wellman, 1977
Rotylenchulus reniformis Linford & Oliveira	PE, US	R	N	N	CABI, 2003

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
Heteroderidae					
Meloidogyne sp.	PE, US	R	Y	N	Delgado and Rosas, 1977; Wellman, 1977
Pratylenchidae					
Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Stekhoven	PE, US	R, S	N	N	CABI, 2003
Radopholus similis (Cobb) Thorne	PE, US (FL, HI, LA, TX)	R, S	N	N	Anonymous, 1984; Anonymous, 1992; CABI, 2003; PIN 309, 2004; Ploetz, *et al.*, 1994;
Trichodoridae					
Trichodorus sp.	PE, US	R	N	N	CABI, 2003
DORYLAIMIDA					
Xiphinematidae					
Xiphinema floridae	PE, US (FL)	R	[Y]	N	Lamberti, *et al.* 1987; Lehman, 2002

Table 3: Pest List - Pests reported on avocado (*Persea americana)* (in any country) and present in Peru on any host.					
Scientific Name, Classification	**Distribution[1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway[4]**	**References**
MOLLUSCA					
Helix aspersa Muller [=Sy. *Cornu aspersum* (Muller)]	PE, US	L, S, R, F, Sd	N[30]	N[17]	CABI, 2003

[1] Distribution: CA = California, FL= Florida, GA = Georgia, HI – Hawaii, NY = New York, PE = Peru, USA = United States of America, TX = Texas.
[2] Plant Part Affected: F = fruit, Flw. = flower or inflorescence, L = leaves, S = stem, R = roots, Sd = seed, Pd = Pod.
[3] Quarantine Pest: Y = yes; N = no; U = Unknown. Brackets indicate that the species, although not fitting the definition of a quarantine pest (IPPC, 2002), is considered actionable (APHIS, PPQ, National Identification Services).
[4] Follow Pathway: Y = yes; N = no; U = Unknown.
[5] Based on biology of *Heilipus catagraphus* (Wysoki *et al*., 2002).
[5a] *H. empiricus* is only mentioned in the literature once by Alata Condor (1973). Our efforts to find more information about this species were unsuccessful. According to SENASA (2005), this species is very rare in Peru and does not pose any economic threat. There is one interception of *Heilipus* sp. on avocado in the passenger luggage from Peru in PIN 309. We did not consider this species for further analysis since it is unlikely that this insect will follow the pathway with imported commodity. However, we reserve the right to add to the pathway any species of *Heilipus* if interceptions of these insects will become recorded on avocados imported from Peru because *H. empiricus* might be misidentification by Alta Condor (1973) of some other species from the genus *Heilipus*.
[5b] We included *Heilipus* sp. in the pest list based on a single interception in a passenger baggage and the evidence is not sufficient to suggest that it will be in the pathway. However, as stated above, we reserve the right to add any species of *Heilipus* to the pathway in the future should their interceptions be found in commercial avocado shipments from Peru. Also, please, see Conclusion section for more information.
[6] Organisms listed at the level of genus (or family), although regarded as quarantine pests because of their uncertain identity, are not considered for further analysis due to the lack of evidence of the risks that they pose (see discussion below).
[7] Based on biology of *Xanthaciura connexionis* (Morin *et al*., 1997).
[8] Courneya, 2004a.
[9] Based on biology of *Hemiberlesia lataniae* (CABI, 2003).
[10] Based on biology of *Ferrisia virgata*.
[11] External feeder; damaged fruits are likely to be eliminated from packing by visual culling.
[12] *Cercospora lingue* is listed in Wellman, 1977, but is not a recognized *Cercospora* fide (Chupp, 1953); consequently, it is not considered for further analysis.

[13] Based upon the biology of *Physalospora pyricola* Nose (Botryosphaeria berengeriana f.sp. pyricola (Nose)

Koganezawa & Sakuma).
[14] Listed as Non-reportable in PIN 309 database. Also, see Courneya (2003)
[15]These species are considered unlikely to follow the pathway because they are secondary pests that attack hosts previously damaged by primary invaders, particularly fruit flies (McAlpine and Steyskal, 1982; White and Elson-Harris, 1992). If damaged fruit is properly culled and fruit fly mitigation is undertaken, then S*ilba* (*Neosilba*) species are not expected to follow the pathway.
[16a] Avocado is a poor host for *A. serpentina* (Bush, 1957; Aluja et al., 2004) therefore it is unlikely that this pest will follow the pathway.
[16b] Avocado is not a natural host for *A. obliqua* (Norrbom, 2004). Only one record exists, for Brazil, for *A. obliqua* on avocado where three "females" were "recovered from host fruit" of unspecified numbers and of unknown variety (Uramoto *et al.*, 2001). This publication is only an abstract and reports "preliminary" results for a previously undocumented host for the fly. There is no specification as to whether the results were based on the adult or larval identifications. It is unknown whether the fruits were from the tree or ground, ripe or immature. No other records are listed in the comprehensive *Anastrepha* species host database of Norrbom (2004). The host status of 'Hass' avocado for *A. obliqua* is not supported in host studies by Aluja *et al.* (2004) conducted in Mexico. We consider (based on the available information) that this species is unlikely to follow the pathway in the avocado fruit.
[17] Because of its size, this pest is not likely to stay on the commodity through harvest and standard handling and processing
[18] This insect is an external pest and affects fruit at the early stages of development by causing fruit darkening or premature drop (Dominguez Gil, 1983). It is unlikely that damaged fruit will not be eliminated after visual culling.
[19] Courneya (2004).
[20] Based on biology of C. *cirripediformis* .
[21] This scale species has been intercepted numerous times on fruit, including fruit in permit cargo, by PPQ at US ports of entry (e.g., PIN309 query July 9, 2003: 7,044 interceptions on fruit).
[22] Courneya, 2004b.
[23] Because of its size, biology, and mobility, this pest is not expected to stay on the commodity through harvest, standard handling and processing. Pentatomidae (species of) has only been intercepted 5 times by PPQ, all of which were in baggage (not cargo) and only one of which was on fruit, which indicates that insects within this family would be unlikely to follow commercial export quality fruit.
[24] The biology (plant part affected) is based on that of Sesia sp. of the same family Sessiidae. Larvae of this family are generally stem borers.
[25] Based on biology of the family Membracidae
[26] *Mycena citricolor* is reported as present in Florida (CABI, 2002). However, expert opinion from Florida indicates that it has not been detected there since 1926 (Schubert, 2002). Also, this species is not listed as attacking avocado or occurring in the United States (Farr et al. 2004, Alfieri et al., 1993; Ploetz et al., 1994)
[27] . The ability of *M. citricolor* to follow the pathway is questionable, as no reference has been found that indicates it attacks avocado fruit specifically. (Mariau, 2001) and (Wellman, 1977) report *M. citricolor* infecting the fruit of coffee, but do not report infection of avocado fruit. Most references refer to *M. citricolor* as a pest of coffee, e.g., (Mariau, 2001; CABI, 2004; Thurston, 1989; Wellman, 1977). Avocado is not listed as a major or even minor host in the CABI (2004). On coffee, sub circular spots initially brown becoming pale-brown to straw-colored are produced mainly on leaves. Similar spots may be produced on stalks and berries. The main effect is to cause leaf fall with a consequent reduction in growth and yield of the coffee tree (CABI, 2004). Although it has been reported in Peru (Farr et al., 2004; CABI, 2004), it has not been intercepted on avocado fruit or any fruit from any country since at least 1985, the earliest APHIS computerized interception data available (PIN309, 2004). Because *M. citricolor* is primarily a leaf spotting disease, primarily a disease of coffee (*Coffea* spp.) and has not been intercepted on avocado fruit by APHIS during the nearly 20 years covered by the PIN 309 database, this pathogen was not considered likely to follow the pathway and was not selected for further analysis.

[28] *Cercospora persae* and *Cercospora purpurea* are sometimes found together on the same leaf, however they are morphologically distinct species (Chupp, 1953).
[29] Potato Spindle Tuber Viroid was declared absent from the United States (NAPPO, 2004a).
[30] Action required to PR, FL, and AL (Courneya, 2004).
[31] Listed as non-reportable (PIN 309, 2005).
[32] The insect is not known to occur in US (HI) as erroneously cited by CABI (2004).
[33] Not reportable (Palm, 2005)

The quarantine pests selected for further analysis are summarized in **Table 4**. Only those quarantine pests that can be reasonably expected to follow the pathway of commercial shipments of export avocado fruit are analyzed further. Other quarantine pests not included in this summary have the potential to be detrimental to U.S. agriculture; however, there were a variety of reasons for not subjecting them to further analysis: the pest's primary association is with plant parts other than the commodity, such as *Aleurodicus cocois*, *Aleurodicus pulvinatus*, *Oligonychus mangiferus*, *Oncideres poecilla*, *Trioza perseae*, *etc.*, which are associated with leaf or stem feeding (Bolland *et al*., 1998; CABI, 2003; Hollis and Martin, 1997; Lopez and Kairo, 1999); pests may be intercepted during inspection by Agricultural Officers as biological contaminants of the commodity (PIN 309, 2003), but biological contaminants are not expected to be present in every shipment.

Also, the biological hazard of organisms identified to the order, family or generic levels was not assessed; however, if pests identified to higher taxa are intercepted in the future, then a reevaluation of their risk may occur. In this risk assessment, this applies to the arthropods *Acutaspis* sp. and *Pinnaspis* sp., and the pathogens *Phomopsis* sp., *Cladosporium* sp., and *Oidium* sp. Generally, the biological hazard of organisms not identified to the species level is not assessed because there are many species within a genus, and it is not reasonable to assume that the biology of all organisms within a genus is identical. The lack of species' identification may indicate the limits of the current taxonomic knowledge, the life stage, or the quality of the specimen submitted for identification. By necessity, pest risk assessments focus on the organisms for which biological information is available. The lack of identification at a specific level does not rule out the possibility that a high risk quarantine pest was intercepted or that the intercepted pest was not a quarantine pest. Conversely, development of detailed assessments for known pests that inhabit a variety of ecological niches, such as the surfaces and/or interiors of fruit, stems or roots, allow effective mitigation measures to eliminate the known organisms, as well as similar, but incompletely identified organisms that inhabit the same niche.

Other plant pests listed in Table 3 that were not chosen for further scrutiny may be potentially detrimental to the agricultural systems of the United States; however, there were a variety of reasons for not subjecting them to further analysis.

In the past, *Anastrepha* species were one of the greatest concerns in allowing the importation of Mexican avocados. A review of the current literature, however, suggests that under most circumstances, Hass avocados do not serve as hosts for *Anastrepha* spp., as indicated by recent laboratory (Aluja *et al.* 2002) and field (Aluja *et al.* 2004) tests conducted in Mexico. The research prompted a re-evaluation of the potential of *Anastrepha* spp. to infest Hass avocado in Mexico. The re-evaluation concluded that uninjured, commercially produced Hass avocados in Mexico do not serve as hosts for the *Anastrepha* spp. in question. Nevertheless, the current re-evaluation of ‘*Anastrepha* sp. - Hass avocado’ relationships is based on experiments conducted in Mexico only, and, therefore, should be extrapolated to other regions of the world with caution, considering that Norrbom (2004) lists a field study by Wille (1952) that shows avocado is a host for the species in Peru. In addition, the Mexican studies indicated that Hass avocado could possibly be a host of *Anastrepha* under some environmental or tree stress circumstances (Aluja *et al.* 2004). *Anastrepha fraterculus* is variable in its pest status in different regions, and isozyme and karyotype studies suggest that what has been considered *fraterculus* consists of several closely similar “sibling species” (Foote *et al*., 1993 and references therein). This species complex has not yet been studied in sufficient detail to permit a clear separation of the included species (White and Elson-Harris, 1992): thus, in Venezuela, Andean and lowland populations are distinct species, and populations from southern and north-eastern Brazil also have marked genetic differences. Also, “there is evidence that the Mexican morphotype differs significantly from South American morphotypes” (Aluja *et al*., 2004 and references therein) and this was one of the reasons why *A. fraterculus* was not investigated in Mexico by Aluja *et al*. (2004). Considering this genetic diversity, data on the suitability of Hass avocado as a host for *Anastrepha* sp. should be provided by Peru based on results of adult fly trappings in avocado groves and fruit cuttings for possible larval infestations.

Table 4. Quarantine Pests Likely to be Associated with avocado imported from Peru	
Arthropods *Acutaspis albopicta* (Hemiptera: Diaspididae) *Anastrepha fraterculus* Wiedemann (Diptera: Tephritidae) *Anastrepha striata* Schiner (Diptera: Tephritidae) *Ceratitis capitata* Wiedemann (Diptera: Tephritidae) *Coccus viridis* (Green) (Hemiptera: Coccidae) *Ferrisia malvastra* (McDaniel) (Hemiptera: Pseudococcidae) *Pseudaonidia trilobitiformis* Green (Hemiptera: Diaspididae) *Stenoma catenifer* Walsingham (Lepidoptera: Oecophoridae)	**Viroid** Potato spindle tuber viroid

5. Consequences of Introduction

The undesirable consequences that may occur from the introduction of quarantine pests is assessed in this section. For each quarantine pest, the potential Consequences of Introduction are rated in five areas called "Risk Elements": climate-host interaction, host range, dispersal potential, economic impact and environmental impact. A cumulative risk rating is then calculated by summing the values; the ratings are summarized in Table 5. The ratings are determined using the criteria in the risk assessment Guidelines, Version 5.02 (USDA, 2000).

The major sources of uncertainty present in this risk assessment are similar to those in other risk assessments: the use of a developing process (USDA, 2000; Orr, *et al*., 1993), the approach used to combine risk elements (Bier, 1999; Morgan and Henrion, 1990), and the evaluation of risk by comparisons to lists of factors within the guidelines (Kaplan, 1992; Orr *et al*., 1993). To address this last source of uncertainty, the lists of factors are interpreted as illustrative and not exhaustive. Another traditionally recognized source of uncertainty is the quality of the biological information (Gallegos and Bonano, 1993), which includes uncertainty whenever biological information is lacking on the regional flora and fauna. Inherent biological variation within a population of organisms also introduces uncertainty (Morgan and Henrion, 1990).

Risk Element #1- Climate-Host Interactions
When introduced to a new area, pests can be expected to behave as they do in their native areas if host plants and climates are similar. Ecological zonation and the interactions of the pests and their biotic and abiotic environments are considered in this element. To rate this element, current distributions of pests and their corresponding climatic zone were found (CABI, 2002) and compared with climatic zones in the United States. The ratings are:

Low (1): Pest can survive in one climatic zone.
Medium (2): Pest can survive in two or three climatic zones.
High (3): Pest can survive in four or more climatic zones.

Risk Element #2- Host Range
The risk posed by a plant pest depends on its ability to establish a viable, reproductive population and its potential for causing plant damage. For arthropods, risk is assumed to be positively correlated with host range. For pathogens, risk is more complex and is assumed to depend on host range, aggressiveness, virulence and pathogenicity; for simplicity, risk is rated as a function of host range.

Low (1): Pest attacks a single species or multiple species within a single genus.
Medium (2): Pest attacks multiple species within a single plant family.

High (3): Pest attacks multiple species among multiple plant families.

Risk Element #3-Dispersal Potential

A pest may disperse after introduction to a new area. The following items are considered: reproductive patterns of the pest (*e.g.*, voltinism, biotic potential); inherent powers of movement; factors facilitating dispersal, wind, water, presence of vectors, humans, *etc.*

Low (1): Pest has neither high reproductive potential nor rapid dispersal capability.
Medium (2): Pest has either high reproductive potential OR the species is capable of rapid dispersal.
High (3): Pest has high biotic potential, *e.g.*, many generations per year, many offspring per reproduction ("r-selected" species), AND evidence exists that the pest is capable of rapid dispersal, *e.g*, over 10km/year under its own power, via natural forces, wind, water, vectors, *etc.*,or human-assistance.

Risk Element #4-Economic Impact

Introduced pests are capable of causing a variety of direct and indirect economic impacts that can be divided into three primary categories (other types of impacts may occur): lower yield of the host crop, *e.g.*, by causing plant mortality or by acting as a disease vector; lower value of the commodity, *e.g*, by increasing costs of production, lowering market price, or a combination; loss of foreign or domestic markets due to the presence of a new quarantine pest.

Low (1): Pest causes any one or none of the above impacts.
Medium (2): Pest causes any two of the above impacts.
High (3): Pest causes all three of the above impacts.

Risk Element #5- Environmental Impact

The assessment of the potential of each pest to cause environmental damage (FAO, 1996) if the introduction of the pest is expected to cause significant, direct environmental impacts, *e.g.*, ecological disasters, reduced biodiversity. When used within the context of the National Environmental Policy Act (NEPA) (7CFR§372), significance is qualitative, encompassing the likelihood and severity of an environmental impact; a pest is expected to have a direct impact on species listed by Federal Agencies as endangered or threatened (50CFR§17.11 and §17.12) by infesting/infecting a listed plant. If the pest attacks other species within the genus or other genera within the family, and preference/no preference tests have not been conducted with the listed plant and the pest, then the plant is assumed to be a host; a pest is expected to have indirect impacts on species listed by Federal Agencies as endangered or threatened by disrupting sensitive, critical habitat. Introduction of the pest would stimulate chemical or biological control programs.

Low (1): None of the above would occur; it is assumed that introduction of a non-indigenous pest will have some environmental impact (by definition, introduction of a non-indigenous species affects biodiversity).
Medium (2): One of the above would occur.
High (3): Two or more of the above would occur.

Figure 2. Plant Hardiness Zones in Peru (source: http://www.backyardgardener.com/zone/sazone.html).

As noted above, *Anastrepha* species have been a primary concern in considering the importation of Mexican avocados. The current re-evaluation of ‘*Anastrepha* sp. - Hass avocado’ relationships is based on experiments conducted in Mexico only and therefore should be extrapolated to other regions of the world with caution. The *A. fraterculus* species complex has not yet been studied in sufficient detail to permit a clear separation of the included species (White and Elson-Harris, 1992). In Venezuela, Andean and lowland populations are distinct species, and populations from southern and north-eastern Brazil also have marked genetic differences. Considering this genetic diversity, data on the suitability of Hass avocado as a host for *Anastrepha* sp. should be provided, if available.

Consequences of Introduction: *Acutaspis albopicta* (Hemiptera: Diaspididae)	**Risk Value**
Risk Element #1: Climate-Host Interaction This insect was reported from New World: Mexico, US (CA, TX), Brazil, Costa Rica, Ecuador, Guatemala, Honduras, Panama, and Peru (USDA, 2003a). Even the least conservative estimate of distribution corresponds to US Hardiness Zones 8-11 (USDA, 1990). The rating is High.	High (3)
Risk Element #2: Host Range The scale is polyphagous and the hosts from following plant families are reported Apocynaceae: *Tabernaemontana*; Araceae: *Aglaonema, Philodendron*; Bromeliaceae: *Tillandsia*; Ebenaceae: *Brayodendron texanum*; Lauraceae: *Persea Americana*; Leguminosae: *Inga*; Menispermaceae: *Hyperbaena denticulate*; Musaceae: *Musa paradisiaca sapientum*: Oleaceae: *Ligustrum vulgare*; Palmae: *Cocos nucifera*; Rubiaceae: *Gardenia jasminoides*; Rutaceae: *Citrus*; Tiliaceae: *Jacquinia* (USDA, 2003a). The rating is High.	High (3)
Risk Element #3: Dispersal Potential Little information is available on the biology of *Acutaspis albopicta* as well as the biology of any other species from this genus. As for other armored scales, it is known that *Pseudaonidia duplex* (Cockerell) has three generations per year in Louisiana; and *P. paeoniae* (Cockerell) has several generations in southern U.S. states and produces 30-50 eggs per female (Kosztarab, 1996). *Acutaspis albopicta* are known to occur on leaves (USDA, 2003a) and fruit: there were more than 2400 of interceptions on different fruits in cargo and baggage including 195 interceptions on avocado fruit alone in permit cargo (PIN 3009, 2004). This information suggests a certain possibility of dispersal via international trade. The species was rated Medium for this risk factor.	Medium (2)

Risk Element #4: Economic Impact This pest is known to affect a lot of ornamental plants as well as commercial fruit trees (USDA, 2003a). There are data on using pesticides on avocado in Mexico against this pest (Seferssa, 2004) which suggests an increase of the cost of production. A presence of this quarantine pest can lead to losses of possible markets. This risk factor was given Medium rating.	Medium (2)
Risk Element #5: Environmental Impact There are two *Gardinia* species from HI listed by USFWS (2004). Some parasitoids (*Aphytis acutaspidis)* are known to attack *Acutaspis albopicta*, however, it is not clear if these parasitoids are possible to use commercially for biological control (Noyes, 2003). Existing chemical control programs for other avocado pests are expected to be sufficient for the *Acutaspis albopicta*.	Medium (2)

Consequences of Introduction: *Anastrepha fraterculus* Wiedemann (Diptera: Tephritidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction The *A. fraterculus* species complex is widely distributed in Central and South America, with restricted distribution in Mexico (CAB, 2001a; Weems, 2002). This group occurs from the south of Texas to Argentina (Foote *et al*., 1993). A conservative estimate is that it should be able to survive in U.S. Plant Hardiness Zones 8-11 (USDA, 1990).	High (3)

Risk Element #2: Host Range *Anastrepha fraterculus* is extremely polyphagous. Preferred hosts include Myrtaceae, *Eugenia* and *Syzygium* spp.and guava. Other hosts of this species are *Terminalia catappa* (Combretaceae), *Malus pumila* and *Prunus* spp. (Rosaceae), *Annona* spp. (Annonaceae), *Citrus* spp. (Rutaceae), *Coffea* spp. (Rubiaceae), *Ficus carica* (Moraceae), *Juglans* spp. (Juglandaceae), *Diospyros kaki* (Ebenaceae), *Manilkara zapota* (Sapotaceae), *Persea americana* (Lauraceae), *Solanum quitoense* (Solanaceae), *Theobroma cacao* (Sterculiaceae), *Olea europaea* (Oleaceae), and *Vitis vinifera* (Vitaceae) (CABI, 2003).	High (3)
Risk Element #3: Dispersal Potential Females deposit from 200 to 400 eggs in host fruits (White & Elson-Harris, 1992). Reproduction is continuous, as adults are present year-round (CABI, 2003). In international trade, the major means of dispersal to previously un-infested areas is the transport of fruit containing larvae. For most regions, the most important fruits liable to carry this species are mango and guava (CABI, 2003).	High (3)
Risk Element #4: Economic Impact *Anastrepha fraterculus* is the most economically important *Anastrepha* in Brazil and other South American countries because of its broad host range (Foote *et al*., 1993). In Brazil, where it causes severe yield losses in apple, the pest is of major concern to growers, and represents a significant constraint to fresh fruit export into countries with quarantine barriers (Sugayama *et al*., 1996). The insect is also an important pest of guava and mango, and to some extent *Citrus* and *Prunus* spp. (CABI, 2003).	High (3)
Risk Element #5: Environmental Impact The extreme polyphagy of this species predisposes it to attack plants in the U.S. listed as Threatened or Endangered, such as *Prunus* (*P. geniculata*, FL), *Eugenia* (*E. koolauensis*, HI), and *Solanum* (Two species, HI) (USFWS, 2003). Its wider establishment in the U.S. likely would lead to the initiation of chemical or biological control programs.	High (3)

Consequences of Introduction: *Anastrepha striata* Schiner (Diptera: Tephritidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction *Anastrepha striata* is found throughout Central America, in South America down to Bolivia and Brazil, and the Netherlands Antilles (CABI, 2003). It is has not yet become established in the U.S. (Foote *et al*., 1993; CABI, 2003). It is estimated this species could survive in U.S. Plant Hardiness Zones 10-11 (USDA, 1990).	Medium (2)
Risk Element #2: Host Range *Psidium guajava* (Myrtaceae) is the primary host (CABI, 2003). Secondary hosts include *Citrus sinensis* (Rutaceae); *Annona muricata* (Annonaceae); *Chrysophyllum cainito* (Sapotaceae); *Prunus persica* (Rosaceae); *Mangifera indica* (Anacardiaceae); *Persea americana* (Lauraceae); *Terminalia catappa* (Combretaceae) (CABI, 2003); *Manihot esculenta* (Euphorbiaceae) (White & Elson-Harris, 1992); *Solanum* sp. (Solanaceae) (Foote *et al*., 1993); and *Passiflora edulis* (Passifloraceae) (Silva *et al*., 1996).	High (3)
Risk Element #3: Dispersal Potential Little information is available on the biology of *A. striata*. Reproduction is continuous, adults occurring throughout the year (CABI, 2003). As in other *Anastrepha* species, long-distance dispersal is accomplished by the movement of immature stages present in consignments of infested fruit. The uncertainty involved in the dispersal potential of this species creates a high risk value.	High (3)
Risk Element #4: Economic Impact Little information is available concerning the economic impact of *A. striata*. Although Weems (1981) stated that the species is not considered to be of primary economic importance, it is reported to be an important pest of guava in Venezuela (Marin Acosta, 1973). Again, due to the uncertainty surrounding the damage potential of this species, this element is given a high value.	High (3)
Risk Element #5: Environmental Impact Because of its broad host range, this species has the potential to attack vulnerable native plants in the U.S., including *Prunus* (*P. geniculata*, FL), and *Manihot* (*M. walkerae*, TX) (USFWS, 2003). As it represents a potential threat to the citrus and stone fruit industries, chemical or biological control programs could be mounted against it.	High (3)

Consequences of Introduction of *Ceratitis capitata* (Diptera: Tephritidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction *Ceratitis capitata* is found in Southern Europe and West Asia, throughout Africa, South and Central America, and in Northern Australia (CABI, 2002). It is estimated this species could become established within U.S. Plant Hardiness Zones 8 – 11 (USDA, 1990).	High (3)
Risk Element #2: Host Range This pest has been recorded on a wide variety of host plants in several families, including Rubiaceae (*Coffea* spp.), Solanaceae (*Capsicum annuum*), Rutaceae (*Citrus* spp.), Rosaceae (*Malus pumila*, *Prunus* spp), Moraceae (*Ficus carica*), Myrtaceae (*Psidium guajava*), Sterculiaceae (*Theobroma cacao*), Arecaceae (*Phoenix dactylifera*) and Anacardiaceae (*Mangifera indica*) (CABI, 2002).	High (3)
Risk Element #3: Dispersal Potential Eggs are deposited in host fruit in small batches of six to eight (Hassan, 1977), around 300 per female (Weems, 1981). In warm climates breeding is continuous throughout the year, as there are several overlapping generations (Hassan, 1977). Adults can fly 20 or more kilometers (CABI, 2002). Transport of infested fruits is the major means of movement and dispersal to previously un-infested areas (CABI, 2002).	High (3)
Risk Element #4: Economic Impact *Ceratitis capitata* is an important pest in Africa, spreading to almost every other continent, making it the single most important pest species in its family (CABI, 2002). In Mediterranean countries, it is particularly damaging to citrus and peach crops. It may also transmit fruit-rotting fungi (CABI, 2002). *Ceratitis capitata* is of quarantine significance throughout the world, especially for Japan and the United States (CABI, 2002). Its presence, even as temporary adventive populations, can lead to severe additional constraints for fruit export (CABI, 2002). In this respect, *C. capitata* is one of the most significant quarantine pests for any tropical or warm temperate areas in which it is not yet established (CABI, 2002).	High (3)

Risk Element #5: Environmental Impact Introduction and establishment of *C. capitata* in the United States would trigger the initiation of chemical control, particularly bait sprays. The species is highly polyphagous, and has the potential to attack plants from genera *Prunus* (*P. geniculata*, FL), *Eugenia* (*E. koolauensis*, HI), *Argemone* (*A. pleiacantha*, NM), *Asimina* (*A. tetramera*, FL), *Berberis* (*B. nevivii*, *B. pinnata*, *B. sonnei*, CA), *Cucurbita* (*C. okeechobeensis*, FL), *Echinocereus* (*E. chisoensis*, *E. reichenbachii*, *E. iridiflorus* – TX; *E. fendleri* – NM; *E. triglochidiatus* – AZ), *Euphorbia* (*E. haeleeleana* – HI; *E. telephioides* – FL), *Gardenia* (*G. brighamii*, *G. mannii*, HI), *Hibiscus* (four species, HI) *Opuntia* (*O. treleasei*, CA), *Santalum* (*S. freycinetianum*, HI), *Solanum* (Two species, HI), *Ochrosia* (*O. kilaueaensis*, HI), *Ribes* (*R. echinellum*, FL, SC), *Scaevola* (*S. coriacea*, HI), *Vicia* (*V. menziesii*, HI), and *Ziziphus* (*Z. celata*, FL); these species are listed by Federal agencies as Threatened or Endangered (USFWS, 2003).	High (3)

Consequences of Introduction of *Coccus viridis* (Green) (Hemiptera: Coccidae)	**Risk Value**
Risk Element #1: *Climate-Host Interaction* This species is pantropical in distribution. It has been reported from India through Indo-China, Malaysia, the Philippines, Indonesia, Oceania and sub-Saharan Africa (CABI, 2003). In the New World, it is present in Florida, and ranges from Mexico and Central America to northern South America and the Caribbean (CABI, 2002). It is estimated that it could become established in U.S. Plant Hardiness Zones 9-11 (USDA, 1990).	Medium (2)
Risk Element #2: *Host Range* This species is polyphagous and has a broad host range. Primary hosts include *Citrus* spp. (Rutaceae), *Coffea arabica* (Rubiaceae), *Artocarpus* sp. (Moraceae), *Camellia sinensis* (Theaceae), *Manihot esculenta* (Euphorbiaceae), *Mangifera indica* (Anacardiaceae), *Psidium guajava* (Myrtaceae), and *Theobroma cacao* (Sterculiaceae) (CABI, 2002). Other hosts include *Alpinia purpurata* (Zingiberaceae), *Chrysanthemum* sp. (Asteraceae), *Manilkara zapota* (Sapotaceae), and *Nerium oleander* (Apocynaceae) (CABI, 2002).	High (3)
Risk Element #3: *Dispersal Potential* Females may deposit up to 500 eggs (CABI, 2002); there may be several generations per year (Kosztarab, 1997). In spite of the slow rate of natural dispersal (Tandon and Veeresh, 1988), the scale can quickly spread through the transport of infested plant materials. *Coccus*	High (3)

viridis has been intercepted numerous times by PPQ on many plants from many countries (PIN 309, 2003).	
Risk Element #4: *Economic Impact* *Coccus viridis* is a major pest of coffee in Haiti (Aitken-Soux, 1985) and India (Narasimham, 1987). In Brazil, infestations of 50 scales per plant caused significant damage to coffee seedlings, reducing leaf area and plant growth rate (Silva and Parra, 1982). *Coccus viridis* is a major cause of yield loss in New Guinea coffee crop (Williams, 1986). In India, the infestation of *C. viridis* and the sooty mold (*Capnodium citri*) that accompanied it significantly altered the quality of citrus fruit (Haleem, 1984).	High (3)
Risk Element #5: *Environmental Impact* As a polyphagous organism, *C. viridis* is likely to attack native plants in the U.S., some of which could be Threatened or Endangered (*i.e., Ochrosia kilaueaensis* – HI; *Illex* – two species, PR; *Senecio layneae* – CA; *Cucurbita okeechobeensis* – FL; *Cordia bellonis* – PR; *Manihot walkerae* – TX; *Scaevola coriacea* – HI; *Hibiscus* – four species, HI; *Eugenia koolauensis* – HI; *E. woodburyana* – PR; *Gardenia* – two species, HI; *Callicara ampla* – PR; *Verbena californica* - CA) (USFWS, 2003). If this species should be introduced to citrus production areas, it could have a negative impact and stimulate the initiation of additional chemical or biological control programs, such as release of preditors (*e.g.,* ladybird *Chilocorus*, caterpillars *Eublemma*, parasites *Coccophagus*, or the parasitic fungus *Cephalosporium lecanii)*.	High (3)

Consequences of Introduction of *Ferrisia malvastra* (McDaniel) (Hemiptera: Pseudococcidae)	**Risk Value**
Risk Element #1: *Climate-Host Interaction* The species is widely distributed in Africa (from South Africa to Israel), Americas (from Argentina to Mexico), Australia, Oceania, and India (USDA, 2003a). It is estimated that it could become established in U.S. Plant Hardiness Zones 8-11 (USDA, 1990).	High (3)
Risk Element #2: *Host Range* This species is polyphagous and has a broad host range. The most important host families include Cruciferae (*Brassica rapa*), Euphorbiaceae (*Euphorbia hirta*, *Manihot esculenta*), Lauraceae (*Persea Americana*), Fabaceae (*Arachis hypogaea*, *Phaseolus vulgaris*), Malvaceae (*Gossypium hirsutum*), Rutaceae (*Citrus paradise*), Solanaceae (*Lycopersicon esculentum*, *Solanum tuberosum*), Chenopodiaceae (*Suaeda monoica*), Compositae (*Erigeron*), Crassulaceae (*Sedum*). (USDA, 2003a)	High (3)
Risk Element #3: *Dispersal Potential* *Data on this species related to dispersal potential are not available; consequently, the analysis for this risk factor is based on information for Ferrisia vigrata.* In India, there are several overlapping generations per year; however, in Egypt, there three generations (CABI, 2003). Fecundity ranges from 109 to 185 eggs per generation, and may exceed 500 (CABI, 2003). The oviposition period is 20-29 days, while the incubation period is about 3-4 hours (CABI, 2003). Nymphs molted 3 (females) and 4 (males) times, and the development period varied from 26-47 and 31-57 days, respectively (CABI, 2003). Longevity of the adult female was 36-53 days and 1-3 days for the male (CABI, 2003). The primary dispersal stage is the first instar, which can be naturally dispersed by wind and animals (CABI, 2003). The females are active and mobile until they start to produce an ovisac and lay eggs (CABI, 2003). All life stages may be carried on consignments of plant material and fruit (CABI, 2003). PIN 309 record lists three interceptions for *Ferrisia malvastra* and 153 for *Ferrisia* sp., with 43 interceptions in commercial and permit cargo. We gave this species High ranking for this risk factor.	High (3)

Risk Element #4: *Economic Impact* *Data on the economic impact of this species are not available; consequently, the analysis for this risk factor is based on information for Ferrisia vigrata.* *Ferrisia virgata* is a known vector of cocoa swollen shoot virus in West Africa and cocoa Trinidad virus in Trinidad (CABI, 2003). It is a pest on coffee in Java, Indonesia, and India (CABI, 2003). In India, *F. virgata* is recorded as a pest of custard, betel vine, black pepper, pigeon pea, milk tree, and rootstock for sapodilla (CABI, 2003); it is also a pest of kenaf (*Hibiscus cannabinus*) and mesta (*H. sabdariffa*) in Bangladesh, of *Leucaena leucocephala* in Taiwan, and of glasshouse ornamental plants in Egypt (CABI, 2003). It is a major pest of irrigated guava trees in the drier areas of the Sudan, where it is common on many other crops, shades, and ornamental and wild plants; in Tanzania, it is a pest of cashew (CABI, 2003). Internationally it is also considered a pest of cotton (CABI, 2003). There is no sufficient evidence on the economic impact of *F. malvastra* which might indicate that this particular species is not a major pest. Taking into account, however, the polyphagy of the pest and its close relatedness to *F. vigrata*, it was given a Medium rating for this risk factor.	Medium (2)
Risk Element #5: *Environmental Impact* As a polyphagous organism, *Ferrisia malvastra* is likely to attack native plants in the U.S., some of which could be Threatened or Endangered. For example, *Hibiscus* (four species, HI), *Euphorbia* (*E. haeleeleana* – HI; *E. telephioides* – FL), *Manihot walkerae*, TX, *Solanum* (two species, HI), *Suaeda californica*- CA, *Erigeron* (*E. decumbens* – OR, *E. maguirei* – UT, *E. parishii* – CA, *E. rhizomatus* – NM), and *Sedum integrifolium* - MN, NY are listed as Threatened or Endangered (USFWS, 2003). Additional introductions (beyond FL) of this species could initiate chemical and biological control, as used for *F. vigrata* (CABI, 2003).	High (3)

Consequences of Introduction of *Pseudaonidia trilobitiformis* (Green) (Hemiptera: Diaspididae)	**Risk Value**
Risk Element #1: Climate-Host Interaction *Pseudaonidia trilobitiformis* has been reported in Mexico, Venezuela the Caribbean (CABI, 2002), East Africa, South East Asia, and New Caledonia in the South Pacific (Fabres, 1974). Suitable climatic conditions for this species include U.S. Plant Hardiness Zones 9-11 (USDA, 1990). One or more of its potential hosts occurs in these zones (USDA NRCS 2003).	Medium (2)

Risk Element #2: Host Range Hosts recorded for this species include *Mangifera indica* and *Anacardium occidentale* (Anacardiaceae), *Citrus* spp. (Rutaceae), *Anthurium andreanum* (Araceae), *Persea americana* (Lauraceae), *Zingiber officinale* (Zingiberaceae), *Theobroma cacao* (Sterculiaceae), *Coffea* spp. (Rubiaceae), *Cocos nucifera* (Arecaceae) (CABI, 2002), *Passiflora* spp. (Passifloraceae) (Hill, 1983), and guava (Myrtaceae) (USDA, 2003a).	High (3)
Risk Element #3: Dispersal Potential No information is available on the biology of this species. A related species, *P. duplex* (Cockerell), exhibits three generations per year in Louisiana; fecundity of *P. paeoniae* (Cockerell) ranges from 30-50 eggs per female (Kosztarab, 1996). Long-distance dispersal of *P. trilobitiformis* is likely transported on infested plant materials.	High (3)
Risk Element #4: Economic Impact *Pseudaonidia trilobitiformis* is regarded as a minor pest of avocado, cacao, citrus, coconut, coffee, mango, and passion fruit (Hill, 1983). The scale is a pest of cashew in Brazil, which requires insecticide treatment for its control (Silva *et al*., 1977). Wider establishment of this insect in the U.S. could cause the loss of domestic and foreign commodity markets, such as citrus.	Medium (2)
Risk Element #5: Environmental Impact Potential hosts listed as Threatened or Endangered in 50 CFR §17.12 include *Zanthoxylum dipetalum* var. *tomentosum* and *Z. hawaiiense* – HI; *Z. thomasianum* – PR, VI; ten species of *Melicope* - HI; *Lindera melissifolia* – AL, AR, FL, GA, LA, MO, MS, NC, SC; and *Ayenia limitaris* - TX (USFWS, 2003). Because *Pseudaonidia trilobitiformis* does represent a potential threat to citrus and other economically important crops, the further establishment of this species in the southern U.S. could stimulate chemical or biological control programs.	High (3)

Consequences of Introduction of *Stenoma catenifer* Walsingham (Lepidoptera: Oecophoridae)	**Risk Value**
Risk Element #1: *Climate-Host Interaction* This moth is distributed in the Western Hemisphere, from Mexico to Brazil (CABI, 2003). Suitable climatic conditions for this species include U.S. Plant Hardiness Zones 9-11 (USDA, 1990).	Medium (2)
Risk Element #2: *Host Range* The seed moth infests species in several genera of Lauraceae: *Beilschmiedia*, *Chlorocardium rodiei* (greenheart tree), *Persea americana* (avocado), *Persea schiedeana* (coyo) (CABI, 2003). This factor was rated Medium.	Medium (2)
Risk Element #3: *Dispersal Potential* Females lay eggs on the skin of the fruit, and the larvae bore into the pulp and seed; on *Persea* (in environmental chamber), there could be approximately 164 eggs laid per female, and up to 206 eggs per female on *Chlorocardium rodiei* (CABI, 2003); females lay up to 206 eggs on *Chlorocardium rodiei* (CABI, 2003). The average life cycle is 46 days with 3 generations per year (FAO, 1999). In tropical regions, this pest is present throughout the year due to the availability of host plants with diverse flowering periods (CABI, 2003). *Stenoma catenifer* populations increase during the growing season, reaching the highest level before harvest (CABI, 2003). Because larvae are internal, *S. catenifer* can be spread worldwide via humans.	High (3)
Risk Element #4: *Economic Impact* *Stenoma catenifer* is a major pest of *Persea americana* in Latin America (CABI, 2003). The proportion of damaged fruit may reach 100% in Brazil (with total fruit loss), 80% in Venezuela, and 100% in Ecuador (CABI, 2003).	High (3)
Risk Element #5: *Environmental Impact* There are no known host plants that are listed as Threatened or Endangered in the U.S. (USFWS, 2003). If *S. catenifer* was introduced, spray programs against adults will be similar to the ones already in existence for avocado pests; it is not expected that Threatened or Endangered species will be affected beyond the impact of programs already in place. However, it is possible that new biological control programs could be developed based on the reports of the larval parasitism in natural populations. For example, in Brazil, natural egg infestations by *Trichogramma pretiosum* and *Trichogrammatoidea annulata* can reach 40% (Hohmann and Meneguim, 1993),	Medium (2)

Consequences of Introduction of *Potato Spindle Tuber Viroid (PSTVd)*	**Risk Value**
Risk Element #1: *Climate-Host Interaction* Climate is not expected to limit the distribution of the viroid. PSTVd is found in a wide range of climates from temperate to tropical (CABI, 2004). Before it was eradicated from the United States it was found in 13 U.S. states from North Dakota to Mississippi which corresponds to more than four hardiness zones.	High (3)
Risk Element #2: *Host Range* The primary natural host of PSTVd is potato, but the viroid also affects tomato and other *Solanum* spp. (Peters and Runia, 1985). The experimental host range of PSTVd includes a wide range of Solanaceous species, as well as species from other families (Singh, 1973). Sweet potatoes (*Ipomoea batatas*) (Convolvulaceae), avocados (*Persea americana*) (Lauraceae) and *Solanum muricatum* have recently been described as hosts, in addition to wild Solanum spp. hosts (Salazar, 1989; Owens et al., 1992; Querci et al., 1995; Behjatnia et al., 1996; Shamloul et al., 1997). The viroid attacks plant hosts from several families therefore the ranking is High.	High (3)
Risk Element #3: *Dispersal Potential* PSTVd is possibly spread by contact between infected and healthy plants (CABI, 2004). There is also a possibility of transmission by pollen or by aphid vectors (in association with PLRV) which is a factor in short distance spread (CABI, 2004). The dispersal potential of the viroid in avocado fruit is unknown. In potato, tubers are the most important means of PSTVd dissemination over both long and short distances (Salazar, 1989). The increased use of true potato seed (TPS) for potato propagation is another potential avenue for spread of the disease if measures are not maintained to certify disease-free status (Singh and Crowley, 1985a; Salazar, 1989).	Medium (2)
Risk Element #4: *Economic Impact* PSTVd can cause up to a 90% yield reduction in avocado (Querci et al., 1994) Losses in potato vary from 3 to 64% (Le Clerg et al.,1944; Singh et al., 1971). However, the severe strain reduced the yield by up to 64%.	High (3)
Risk Element #5: *Environmental Impact* There are no known host plants that are listed as Threatened or Endangered in the continental U.S. (USFWS, 2003). The environmental impact of the pathogen is likely to be minimal since the disease used to be widely spread throughout North America (CABI, 2004).	Low (1)

Table 5. Summary of the Risk Ratings and Values for the Consequences of Introduction

Pest	Climate / Host	Host Range	Dispersal Potential	Economic Impact	Environ-mental Impact	Consequences of Introduction Value[1]
Acutaspis albopicta	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Anastrepha fraterculus	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Anastrepha striata	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (14)
Ceratitis capitata	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Coccus viridis	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (14)
Ferrisia malvastra	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (14)
Pseudaonidia trilobitiformis	Medium (2)	High (3)	High (3)	Medium (2)	High (3)	High (13)
Stenoma catenifer	Medium (2)	Medium (2)	High (3)	High (3)	Medium (2)	Medium (12)
Potato Spindle Tuber Viroid	High (3)	High (3)	Medium (2)	High (3)	Low (1)	Medium (12)

[1] Low is 5-8 points, Medium is 9-12 points and High is 13-15 points

6. Likelihood of Introduction

The value for the Likelihood of Introduction is the sum of the ratings for the Quantity Imported Annually and the Pest Opportunity (Table 6). The following scale is used to interpret this total: Low 6-9 points, Medium 10-14 points and High 15-18 points.

The likelihood that an exotic pest will be introduced depends on the amount of the potentially-infested commodity that is imported. Usually, the rating for the **Quantity Imported Annually** is based on the amount reported by the country of proposed export, and is converted into a standard unit of 40-foot long shipping containers.

Scoring is as follows:
Low (1): <10 containers per year
Medium (2): 10-100 containers per year
High (3): >100 containers per year.

Quantities of avocado that can be exported from Peru to the U.S. yearly (SENASA, 2002a):

Season	Number of 40 ft. Containers
2003	250
2004	375
2005	500

This risk factor is therefore rated High.

The assessment of **Pest Opportunity** considers ratings in five areas. The ratings for Pest Opportunity are based on the biological features exhibited by the pest’s interaction with the commodity, and represent a series of independent events that must take place before a pest outbreak can occur. The five components of Pest Opportunity consider the availability of postharvest treatments, whether the pest can survive through the interval of normal shipping procedures, whether the pest can be detected during a port-of-entry inspection, the interactions among factors that influence the rate of establishment, and the factors that influence the rate of population establishment.

Anastrepha fraterculus, A. striata, Ceratitis capitata, and *Stenoma catenifer* are rated High (3) for their ability to **Survive Postharvest Treatment** because the larvae are internal feeders that are not likely to be affected by a surface-cleansing postharvest treatment, such as washing and culling, especially if the extent of the damage is not very obvious. The pests *Coccus viridis* (Coccidae), *Ferrisia malvastra* (Pseudococcidae) and Diaspididae *Acutaspis albopicta* and *Pseudaonidia trilobitiformis* are rated

Medium (2) because they are external feeders that are likely to be dislodged by a surface-cleansing postharvest treatment; however, depending on their stage (egg, immature, adult) or instar, these insects might find shelter on fruit, particularly at the calyx end, on a bumpy surface or in packing materials. The Coccoidea have sessile stages that live firmly pressed to plant surfaces; this posture and their water-repellent, waxy cuticles can make them difficult to see or dislodge, especially if sheltered at the stem end of the fruit. Potato Spindle Tuber Viroid (PTSVD), like other viruses or viroids, is expected to survive treatment and is therefore ranked High.

All of the pests are rated High (3) for the ability to **Survive Shipment.** The internal feeders are protected from adverse environmental conditions by the plant part tissue, while other pests are expected to take shelter in rough or pitted areas on the plant part surface. Fruit can be shipped by airfreight, which makes delivery time short, and may or may not be refrigerated. The temperature conditions and time frames associated with un-refrigerated air or sea transport are insufficient to reduce population levels of these pests. Further evidence of the ability of numerous pests to survive with avocado fruit shipments is in the fact that, since 1985, agricultural officers at US ports-of-entry have made 17,402 pest interceptions on avocado fruit, including permit and general cargo, stores, quarters, mail, and passenger baggage (PIN 309, interception query August 17, 2004). Interceptions from South America are presented in Appendix 1. PSTVd replicates autonomously and moves systemically within the plant. The viroid would be expected to survive shipment and is therefore ranked High.

The pests *Anastrepha fraterculus, A. striata, Ceratitis capitata,* and *Stenoma catenifer* are rated High (3) for **Not Detected at the Port-of-Entry** because these insects are internal pests that are only intercepted by destructive sampling. Depending on the age of infestation, the fruit fly pests can have a high probability of escaping detection at a port-of-entry; fruit fly-infested fruit can go unrecognized (White and Elson-Harris, 1992). Staining of fruits by sooty molds and large, obvious infestations can lead to the easy detection of armored scales *Acutaspis albopicta* and *Pseudaonidia trilobitiformis* (Diaspididae), mealybug *Ferrisia malvastra* (Pseudococcidae) and soft scales *Coccus viridis* (Coccidae); however, sparser populations of these relatively small insects (especially eggs and early instars), particularly if concealed at the stem end of fruits or in packing materials, would be more difficult to discover, despite the color differences with the plant part; as a result, these pests are rated Medium (2). PSTVD may not be detected upon entry. PSTVD has been found in potato seed (CABI, 2004). While some avocado fruits exhibit pronounced symptoms (Querci *et al*., 1995), these fruits are unlikely to be packed. It is unclear if asymptomatic fruit may contain viable inoculum quantities, so consequently this criterion is ranked Medium.

Based on their known distributions in warm temperate and tropical climates, all of the arthropods, except *Stenoma catenifer*, are rated Medium (2) for their ability to be **Moved to a Suitable Habitat** due to their need for specific temperature ranges. In addition to their warm climate requirements, *Stenoma catenifer* is known to feed on only avocado, and, therefore, will only survive in areas where avocado is produced; thus, this pest is rated Low (1) for this risk factor. Information is not available for the distribution of possible markets for this commodity, therefore we considered all of the continental US to be a possible market. Based on this assumption, it is likely that areas suitable for these pests to establish permanent populations will include only a rather narrow part of the country in the South and along the West Coast of the continental U.S. and in Hawaii, which would comprise less than an estimated 15% of the total land area of the U.S. PSTVD can be a pest in a broad range of climates so there is a High (3) likelihood of it being moved to a suitable climate.

Ability to come into **Contact with Host Material** will vary among the arthropods in their potential geographic range within the U.S. Hosts of the extremely polyphagous species *Anastrepha fraterculus*, *A. striata*, *Ceratitis capitata*, include temperate-zone or widely cultivated plants (USDA, 2003b) and should be available throughout the potential range. The pests are rated High (3).

Hosts of the *Coccus viridis, Acutaspis albopicta* and *Pseudaonidia trilobitiformis* are of more limited distribution in the U.S., and are less likely to be encountered and colonized within the potential geographic range. Hosts of *Ferrisia malvastra* include some temperate-zone or widely cultivated plants (USDA, 2003b), however, although the hosts could be available for colonization, biological attributes of Coccoidea reduce their probability of successful establishment in the U.S. Specifically, their sessile nature would greatly limit the chances of coming into contact with hosts (Miller, 1985; Gullan and Kosztarab, 1997). Successful establishment of these insects in a new environment is dependent on the likelihood of at least two necessary conditions: close proximity of susceptible hosts and presence on the imported fruit of 'crawlers' (or other mobile forms) to transfer to new hosts. Since these circumstances are highly unlikely to co-occur (Miller, 1985), all scale insects are given a risk rating of Low (1) for this element.

PSTVd is unlikely to come into contact with hosts. In potato, natural spread of PSTVd is through seed or aphid transmission (CABI, 2004). PSTVd and a related viroid Avocado Sunblotch Viroid (ASBVd) are known to be transmitted through seed or pollen of infected plants (Desjardins et al., 1984; Fernow et al., 1970). Establishment would require infected seed or fruit tissue to come into contact with a host. This may require propagation of the seed rather than normal disposal; hence the risk should be considered Low (1).

As mentioned above, *Stenoma catenifer* is known to feed on only avocado and will therefore only survive in areas where avocado is produced. For this reason, it is rated Low (1) for this factor.

Table 6. Summary of the ratings for the Quantity Imported Annually, the Pest Opportunity, and the value for the Likelihood of Introduction.

Pest	Quantity Imported Annually	Ratings for Pest Opportunity					Likelihood of Introduction Value
		Survive Postharvest Treatment	Survive Shipment	Not detected at the Port-of-entry	Moved to a Suitable Habitat	Contact with Host Material	
Acutaspis albopicta	High (3)	Medium (2)	High (3)	Medium (2)	Medium (2)	Low (1)	Medium (13)
Anastrepha fraterculus	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (17)
Anastrepha striata	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (17)
Ceratitis capitata	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (17)
Coccus viridis	High (3)	Medium (2)	High (3)	Medium (2)	Medium (2)	Low (1)	Medium (13)
Ferrisia malvastra	High (3)	Medium (2)	High (3)	Medium (2)	Medium (2)	Low (1)	Medium (13)
Pseudaonidia trilobitiformis	High (3)	Medium (2)	High (3)	Medium (2)	Medium (2)	Low (1)	Medium (13)
Stenoma catenifer	High (3)	High (3)	High (3)	High (3)	Low (1)	Low (1)	Medium (14)
Potato Spindle Tuber Viroid	High (3)	High (3)	High (3)	Medium (2)	High (3)	Low (1)	High (15)

[1] Low: 6 - 9 points, Medium: 10 - 14 points, High: 15 - 18 points

Port-of-entry inspection will probably be inadequate to provide phytosanitary security for all quarantine pests that are likely to follow the pathway; therefore, the development of specific phytosanitary measures is recommended. Postharvest mitigation measures to reduce infestations of external and internal feeders are necessary and should be implemented for imports to be authorized.

7. Conclusion: Pest Risk Potential and Phytosanitary Measures

The summation of the values for the Consequences of Introduction and the Likelihood of Introduction gives values for Pest Risk Potential (Table 7). The following scale is used to interpret this total: Low 11-18 points, Medium 19-26 points and High 27-33 points. This is a baseline estimate of the risks associated with this importation, and the reduction of risk occurs through the use of mitigation measures.

Table 7. Pest Risk Potential

Pest	**Consequences of Introduction**	**Likelihood of Introduction**	**Pest Risk Potential**
Acutaspis albopicta	Medium (12)	Medium (13)	Medium (25)
Anastrepha fraterculus	High (15)	High (17)	High (32)
Anastrepha striata	High (14)	High (17)	High (31)
Ceratitis capitata	High (15)	High (17)	High (32)
Coccus viridis	High (14)	Medium (13)	High (27)
Ferrisia malvastra	High (14)	Medium (13)	High (27)
Pseudaonidia trilobitiformis	High (13)	Medium (13)	Medium (26)
Stenoma catenifer	Medium (12)	Medium (14)	Medium (26)
Potato Spindle Tuber Viroid	Medium (12)	High (15)	High (27)*

* Determined to be Low based on data presented in Appendix 2.

Specific phytosanitary measures may be necessary for pests with a baseline Pest Risk Potential of Medium (*Acutaspis albopicta*, *Pseudaonidia trilobitiformis* and *Stenoma catenifer*). All the fruit fly pests in this risk assessment (*Anastrepha fraterculus*, *Anastrepha striata*, *Ceratitis capitata*) and the scale *Coccus viridis* had analysis values within the High range for their Pest Risk Potential. The Guidelines (USDA, 2000) state that a High Pest Risk Potential means that specific phytosanitary measures are strongly recommended, and that port-of-entry inspection is not considered sufficient to provide phytosanitary security.

It is important to note that any species of *Heilipus* seed beetles may later be considered to follow the pathway if interceptions of these insects are recorded on avocados imported from Peru. We included

Heilipus sp. in the pest list based on a single interception on avocado from Peru in a baggage but we consider that this single interception record is not a sufficient reason for the pest to remain in the pathway. We have a high degree of uncertainty associated with the *Helipus* species based mostly on a lack of sufficient evidence about this genus in Peru and its economic importance there. Likewise, there is an uncertainty about other genera of seed weevils which could be associated with avocado in Peru. For example, species of *Conotrachelus* had been intercepted from Peru in permit and commercial cargo of different commodities, other than avocado (PIN 309, 2005). At this time, we do not have any information on the species of *Conotrachelus* that occur in Peru and feed on avocado. We therefore did not include any species from this genus in the pest list. Species from the genus *Conotrachelus*, however, are well known pests of avocados (Wysoki *et al.,* 2002) and one or more of these species (PIN 309, 2005) might occur on avocados in Peru. Seed weevils from genera *Heilipus* and *Conotrachelus* are known to be in the pathway on avocados imported in the United States from other countries (7 CFR §319.56; PIN 309, 2005). In the following section, we suggest including provisionary phytosanitary measures to mitigate any possible risk posed by seed weevils until sufficient evidence is available to indicate that they do not follow the pathway.

The conclusions from pest risk assessment are used to decide whether risk management is required and the strength of measures to be used (Stage 2 of PRA) (IPPC, 1996). Pest risk management (Stage 3 of PRA) is the process of identifying ways to react to a perceived risk, evaluating the efficacy of these procedures, and recommending the most appropriate options (IPPC, 1996, 2002). The Risk Management Section (below) describes risk mitigation options with discussions of their efficacy and application.

III. Risk Mitigation

The appropriate level of protection for an imported commodity can be achieved by the application of a single phytosanitary measure, such as inspection, quarantine treatment, or a combination of measures. Specific mitigations may be selected from a range of pre-harvest and post-harvest options, and may include other safeguarding measures. Measures may be added or the strength of measures may be increased to compensate for uncertainty associated with evidence of a risk. At a minimum, for a measure to be considered for use in a systems approach, it must be: 1) clearly defined; 2) efficacious; 3) officially required (mandated); and 4) subject to monitoring and control by the responsible national plant protection organization (IPPC, 2002).

A systems approach to mitigate risks involved with mature green 'Hass' avocado imports from Peru might combine a variety of measures: 1) certification of pest-free areas, pest-free places of production, or areas of low pest prevalence for certain quarantine pests; 2) programs to control pests within orchards (*e.g.*, mechanical, chemical, cultural); 3) preclearance oversight by USDA-APHIS officials; 4) packinghouse procedures to eliminate external pests (*e.g.*, washing, brushing, inspection of fruit); 5) quarantine treatments to disinfest fruit of internal and external pests; 6) consignments inspected and certified to be free of quarantine pests; 7) fruit traceable to origin, packing facility, grower, and field; 8) consignments subject to sampling and inspection after arrival in the United States; and 9) limits on distribution and transit within the United States.

Phytosanitary Measures Prior to Harvesting

Pest-free Areas: Establishment of pest-free areas, pest-free places of production, and pest-free production sites, as well as areas of low pest prevalence, may be an effective alternative to post-harvest quarantine treatments or a component of systems approach (IPPC, 2002). Establishment and maintenance of such pest-free areas or production sites should be in compliance with ISPM Nos. 4, 10 and 22 (IPPC 1996, 1999, and 2005) and NAPPO Standard 17 (NAPPO 2004b). Export from Peru should be considered only from production areas that participate in the Integrated Fruit Fly Management program. Currently, this program includes trappings for fruit flies during the avocado growing season (SENASA, 2005). We consider that a pre-harvest trapping program could be as important as the monitoring the population levels during the harvest season. Overall, the trapping schedules should satisfy the requirements of the appropriate international and regional standards, such as those mentioned above.

<u>Fruit flies *Anastrepha fraterculus*, *Anastrepha striata* and *Ceratitis capitata*</u>
Basic requirements for the trapping program for establishing fruit fly pest free areas (PFA) could be found in the standard 17 of the NAPPO (2004b). Specific trapping levels for *Anastrepha* spp. and *Ceratitis capitata* should be identified in the Workplan and are not discussed in this document. In addition to the trappings, an exclusion of untreated host fruit imports into PFA is required. Also, mandatory are treatments of all capture sites and strict increase of trapping levels at first capture, trapping in pueblos as well as in orchards, suspension of exports on second capture in 1 sq mile in the same life cycle. We suggest a periodic APHIS review of the program and possibly a pre-clearance of shipments.

<u>Seed moth *Stenoma catenifer* and seed weevil *Heilipus*</u>
Establishment of Pest free area for these pests should be based on official sample prior to export season, orchard cleanliness, verification sampling and inspection of lots at harvest; certification of being harvested from pest free place of production. Inspecting avocados for seed weevils of genus *Heilipus* could be conducted at the same time as cuttings are done to inspect for the presence of the seed moth, *Stenoma catenifer,* and fruit flies. In addition to *Helipus*, there might be other, unidentified, species of weevils found in the avocado fruit during such inspections. We recommend professional identification of these insects in order to avoid introduction of any quarantine pests in the

United States. Screening for the seed weevils should be a provisional measure to determine if these pests occur in the pathway.

The municipality must be surveyed at least annually and found to be free from the weevils and the seed moth. The survey must cover certain area (as stated in the Workplan) and include randomly selected portions of each registered orchard and areas with wild or backyard avocado trees. The survey must be conducted during the growing season and completed prior to the harvest of the avocados. Specifics for this survey could be similar to those approved for the importation of Hass avocados from Mexico into the United States as described in the latest Code of Federal Regulations (CFR, 2003).

A second option is a Pest-free place of production. This is based on a higher level of official sampling, orchard cleanliness, and higher levels of verification samplings and inspections of lots at harvest as well as a phytosanitary certification of production in a pest free place.

Scales *Coccus viridis* and *Ferrisia malvastra*
Effective IPM programs achieving low pest prevalence of these scales combined with inspection is a possible mitigation option. Freedom from the scales could be verified by conducting an official survey or lot freedom based on inspection of shipping lot.

Armored scales *Acutaspis albopicta* and *Pseudaonidia trilobitiformis*
No mitigation is needed in avocado fruit shipments since PPQ does not take actions against these pests.

Control Program: Mechanical, cultural, or chemical means (*e.g.*, orchard sanitation, pre-harvest insecticidal, fungicidal, and herbicidal sprays) should be used to control pests within the orchards routinely to achieve pest-free areas or pests-free production sites. Sanitation and pesticide applications, as essential components of best management practices, are mainstays of commercial fruit production (*e.g.*, Kirk *et al*., 2001).

Phytosanitary Certification Inspections: Fruit should be sampled and inspected periodically during the growing season and after harvest for quality control and as phytosanitary precautionary measures. Orchards should be surveyed periodically; at these times, a random sample of fruit per tree will be inspected to detect for presence of quarantine pests. Results of surveys must be negative for quarantine pests. Production areas also should be subject to scheduled audits and periodic, unannounced inspections by certified inspectors from PPQ and SENASA; these inspections will insure that production areas will meet stipulated requirements for the issuance of a phytosanitary certificate required for each consignment. This measure is useful for detecting pests present during the growing season that may be more difficult to detect post-harvest. Detection methods need to be combined with other measures to ensure the absence of pests of concern. Statistical procedures are available to verify, to a specified confidence level, the pest-free status of an area, given negative survey or trapping results (Barclay and Hargrove, 2005).

Mitigation Options Post-harvest and Prior to Shipping

Post-harvest Safeguards and Packinghouse Procedures: Removal of infected or infested plant material reduces the likelihood that quarantine organisms would be present with a shipment. Routine post-harvest and packing practices for avocados to be exported to the United States should include the safeguards similar to those applied for avocados imported from Mexico (CFR, 2003).

For example, avocado fruit that has fallen from the trees must be removed from the orchard at least once every 7 days and may not be included in field boxes of fruit to be packed for export. Harvested avocados must be placed in field boxes or containers of field boxes that are marked to show a registration number of the orchard. The avocados must be moved from the orchard to the packinghouse within 3 hours. of harvest or they must be protected from fruit fly infestations until moved.

The avocados must be protected from fruit fly infestations during their movement from the orchard to the packinghouse and must be accompanied by a field record indicating that the avocados originated from a certified orchard.

The packinghouse may accept fruit only from orchards certified for participation in the avocado export program. All openings to the outside must be covered by screening with openings of not more than 1.6 mm or by some other barrier that prevents insects from entering the packinghouse. The packinghouse must have double doors at the entrance to the facility and at the interior entrance to the area where the avocados are packed.

Prior to the culling process, a sample of 300 avocados per shipment must be selected, cut, and inspected to be found free from quarantine pests (particularly internal feeders such as fruit flies, seed moth and seed weevils). The identity of the avocados must be maintained from field boxes or containers to the shipping boxes so the avocados can be traced back to the orchard of origin if pests are found at the packinghouse or the port of first arrival in the United States.

Prior to being packed in boxes, each avocado fruit must be cleaned of all stems, leaves, and other portions of plants to remove external pests. Most avocado fruit can be cleaned by gently wiping the surface with a clean soft cotton cloth or gloves. It may be necessary to use a moist cloth if the dirt particles or surface stains are difficult to remove. The cloth should periodically be dipped in a mild solution of household bleach (150 ppm hypochlorous acid or household bleach) to minimize the spread of possible latent diseases. Larger-scale operations may choose to clean the avocados by handrubbing individual fruit dumped in a tank of sanitized water. The wash water should be sanitized with 150 ppm hypochlorous acid (household bleach) maintained at a pH of 6.5. This is equal to 2 oz of household bleach (such as Marvex) per 5 gallons of water, or .3 liters of bleach per 100 liters of water. Avocadoes can also be cleaned mechanically by passing the fruit over a series of roller brushes wetted from above with spray nozzles (GMC, 2006).

During the grading process, any damaged, diseased, or infested fruit will be removed and separated from the commodity destined for export. Each selected fruit should be labeled with a sticker that bears registration number of the packinghouse. Any avocados that have not been packed or loaded into a refrigerated truck or refrigerated container by the end of the work day must be kept in the screened packing area.

Mitigation Options during Shipping and at U.S. Ports-of-entry: The boxes must be placed in a refrigerated truck or refrigerated container and remain in that truck or container while in transit to the port of first arrival in the United States. Prior to leaving the packinghouse, the truck or container must be secured with a seal that will be broken when the truck or container is opened. Once sealed, the refrigerated truck or refrigerated container must remain unopened until it reaches the port of first arrival in the United States. Each shipment of avocado must be accompanied by a phytosanitary certificate issued by SENASA stating that all of the conditions of the Workplan have been met.

Limits on Distribution and Transit within the United States: In some instances, the importation of commodities that might be harboring exotic pests is authorized for shipment only to certain locations (*e.g.,* Alaska or North Atlantic ports) or during a specific season (usually the one with the coldest temperatures). These additional measures limit the risk of establishment for many exotic pests. The importation of avocados into the United States is anticipated during the harvest season in Peru, which is during May – August, with the peak harvest during June and July. These months are warmest in the continental United States and could be very suitable for survival of exotic pests. Shortening the importation season to May only and confining shipments to Alaska and North Atlantic ports during these months could somewhat increase the level of protection.

Point-of-entry Sampling and Inspection: Upon arrival in the United States, consignments will be inspected, with particular attention given to paperwork, to ascertain that the chain of custody has remained intact. A random sample of fruit from each consignment might be inspected (depending on the Workplan conditions) to detect a pest infestation rate of 10% or greater (USDA, 2004).

Quarantine treatments:
<u>Fumigation and Refrigeration</u>: Treatments of avocado against Mediterranean fruit fly, *Ceratitis capitata*, and melon and oriental fruit flies is governed by the rule 7CFR319.56-2o (CFR, 2006). **Fumigation** with methyl bromide at normal atmospheric pressure followed by **refrigerated storage** in

accordance with the procedures described in this section of CFR (2006) is effective against the above mentioned fruit flies but is not effective against other dangerous pests of avocado. Accordingly, this treatment will be approved for treatment of avocados in connection with the issuance of permits under Sec. 319.56-3 for the importation of avocados from any country when it is determined that the pest risk involved in the proposed importation is such that it will be eliminated by this treatment.

The fumigant shall be methyl bromide applied at normal atmospheric pressure with the dosage of two pounds per 1,000 cubic feet for 2\1/2\ hours at 70^{o} F or above. At the conclusion of the 2\1/2\-hour exposure period, the avocados will be aerated for minimum of 30 minutes. Avocados to be fumigated shall be restricted to fruit at the mature green stage of development and be arranged in ventilated wooden boxes, without packing material or wrappings. The refrigerated phase of the treatment shall consist of refrigeration for 7 days at 45^{o} or below. Cooling of the fruit must begin within 24 hours following the fumigation. The refrigerated storage shall consist of 7 days at fruit pulp temperature of 45^{o} F or below. The time required to cool the pulp temperature to 45^{o} F or below may be included in the 7-day period provided the cooling is accomplished in 24 hours or less.

For avocados from Peru, this specific treatment should be effective only against *Ceratitis capitata*. There is no data available at the moment for the efficacy of this treatment against the fruit flies *Anastrepha* spp. and the moth *Stenoma catenifer* on avocado.

There are, however, many treatments available against *Anastrepha spp.* in other fruits and vegetables. For citrus, for example, the treatment is **T101-j-2-1**, which is fumigation with methyl bromide at NAP—chamber at 80—85^{o} F with the condition that the infestation level is less than 0.5 percent of the lot. Another option for citrus is to treat Anastrepha spp. with high-temperature forced air treatment (Treatment: T103-a-1). For mango, to treat against *Anastrepha* spp., available treatment is **T102-a** Hot water dip. Apples, grapes, apricots, tangerine and other fruits could be subject to different schedules of Cold treatment against *Anastrepha* spp. Specific efficacy data are needed to verify that any of the available treatments against *Anastrepha* spp. could be used for treating this group of pests in avocado.

Treatment **T104-a-1 and T104-a-2** with methyl bromide at NAP–tarpaulin or chamber are approved by APHIS for scale insects (*Coccus viridis*) and mealybugs (*Ferrisia malvastra*) at 70° F or above (maximum dosage, 2 pounds/1,000 ft^3), for 0.5 or 2.0 hours, depending on concentration readings.

<u>Irradiation:</u> Recently approved irradiation treatment with the generic dose of 400 Gy for all pests of the phylum Arthropoda, excluding adults and pupae of the order Lepidoptera could be a valuable option for controlling external pests *Coccus viridis* and *Ferrisia malvastra* and fruit flies *Anastrepha* spp., and *Ceratitis capitata* (Shea, 2006). The treatment should be also effective against moth *Stenoma catenifer* since only larvae of this pest are present in the fruit and their pupation occurs in the

soil (CABI, 2005). Avocado, however, is sensitive to irradiation, thus more research is needed to identify a lower irradiation dose for the pest complex to preserve the fruit quality. For example, 150 Gy could be used for the fruit flies (Shea, 2006) combined with the field control leading to a low prevalence for other pests. In addition, an inspection should be required.

3. Monitoring

Pre-shipment Programs: Inspection, treatment, or other mitigative measures performed in the field and packinghouse should be under the direct supervision of qualified APHIS and SENASA personnel, and in accordance with specified phytosanitary procedures. Such programs call for monitoring of all aspects of any required phytosanitary measures, in addition to identifying the shortcomings and opportunities for program modifications. Provisions should be made for the formal recognition of approved areas, sites, or producers, as well as the specification of conditions for revoking approvals or refusing certification for export to the United States.

Field Survey and Trapping: Survey procedures include visual inspection, fruit cutting, and field trapping. Surveys should be conducted at regular intervals during the growing season to determine the presence or absence of pests. Specific methodologies of trappings and surveys for each quarantine pest of concern should be outlined in the Workplan. Growers will receive or be denied certification for export on the basis of survey or trapping results.

Shipments Traceable to Place of Origin in Peru: A system of identification labels and record keeping is required for avocado indicating the specific place of origin to ensure traceability to each production site.

4. Conclusions

The number and diversity of pests that require mitigation make it unlikely that a single mitigative measure will be adequate to reduce risks of their introduction into the United States. For this reason, a combination of measures in a systems approach is most feasible. The system should include the following safeguards: monitoring of orchards and management programs to achieve and maintain area pest freedom; packinghouse inspection and post-harvest treatments; and maintenance of consignment security and traceability in transit.

This document does not purport to establish specific work plans or to evaluate the quality of a specific program or systems approach. It identifies risks and provides information regarding known mitigative measures. The specific implementation of measures, as would be present in an operational Workplan, is beyond the scope of this document.

Table 8. Summary of Risk Mitigative Options for Avocado, *Persea americana*, from Peru.

Measure(s)	Pest	Efficacy
Pest-free areas or places of production	All	Satisfies requirements for appropriate level of protection
Control program, including mmechanical, cultural, or chemical means, and monitoring	All	Research required to demonstrate efficacy
Fruit cutting samples	*Anastrepha* spp., *Ceratitis capitata*, *Stenoma catenifer*, *Heilipus* spp.	Adequate sampling size satisfies requirements for appropriate level of protection
Packinghouse procedures, including cleaning, visual culling, brushing	External feeders *Coccus viridis* and *Ferrisia malvastra*	Research required to demonstrate efficacy on avocado. Washing with warm soapy water and brushing is used extensively against these pests in foliage and cut flowers.
Point-of-entry sampling and inspection including fruit cuttings	Most of the external pests; most of the internal pests when fruit is cut	Certain small insects, such as scales demonstrate low rate of detection during routine visual inspections. Shaker-box technique and/or microscopic evaluations might be needed to reduce level of risk. For cut fruit, sample size should be adequate to detect infestation
Irradiation, generic dose 400 Gy, combined with low pest prevalence	All pests	Approved by APHIS. Due to sensitivity of avocado to irradiation, data are needed to identify a lower specific doze.
Irradiation 150 Gy for fruit flies combined with low prevalence of other pests plus inspection	All pests	Research required to demonstrate efficacy
Methyl-Bromide fumigation (T104-a-1, schedule for mealybugs) combined with low pest prevalence	*Coccus viridis*	Approved by APHIS to treat surface pests such as scales on vegetables, including avocado.

Methyl-Bromide fumigation (T104-a-2, schedule for mealybugs) combined with low pest prevalence	*Ferrisia malvastra*	Approved by APHIS to treat mealybugs
Fumigation with Methyl-Bromide followed by cold treatment	*Ceratitis capitata*	Approved by APHIS to treat certain fruit flies in avocado.
Methyl-Bromide fumigation, or hot water dip, or high temperature forced air	*Anastrepha* spp.	Different schedules approved by APHIS for a number of fruits. Research required to demonstrate efficacy on avocado

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Appendix 1

Pest interceptions from South America including Peru, based on data from the PIN 309 database (PIN309 query date?).

PEST	BOL	BRA	CHI	COL	ECU	PER	VEN	Total
Abgrallaspis sp. (Diaspididae)			1		1			2
Agrotis sp. (Noctuidae)			3					3
Anastrepha sp. (Tephritidae)					2	1	1	4
Apion sp. (Curculionidae)			1					1
Arhyssus tricostatus (Spinola) (Rhopalidae)			1					1
Athlia rustica erichson (Scarabaeidae)			1					1
Aulacaspis tubercularis newstead (Diaspididae)			1					1
Blapstinus punctulatus solier (Tenebrionidae)			3					3
Blapstinus sp. (Tenebrionidae)			1					1
Bruchidae, species of			1					1
Cerambycidae, species of			1					1
Ceratitis capitata (Wiedemann) (Tephritidae)		1						1
Cladosporium sp.						1	1	2
Coccotrypes sp. (Scolytidae)							1	1
Coelomycetes, species of		1						1
Conoderus rufangulus (Gyllenhal) (Elateridae)			1					1
Conotrachelus sp. (Curculionidae)					3			3
Copitarsia sp. (Noctuidae)			7					7
Crambidae, species of			1					1
Curculionidae, species of						1		1
Diaspididae, species of		1				1	1	4
Diaspis sp. (Diaspididae)			1					1
Elateridae, species of			1					1
Gelechiidae, species of	1		1	1				3
Grammophorus minor (Schwarz) (Elateridae)			1					1
Gryllus sp. (Gryllidae)			2					2

PEST	BOL	BRA	CHI	COL	ECU	PER	VEN	Total
Hadeninae, species of (Noctuidae)			6					6
Heilipus sp. (Curculionidae)				1		1		2
Hemiberlesia diffinis (Newstead) (Diaspididae)					1			1
Homoptera, species of				1				1
Hoplosphyrum griseus (Philippi) (Gryllidae)			6					6
Hylurgus ligniperda (Fabricius) (Scolytidae)			1					1
Lepidoptera, species of			1					1
Lepidosaphes sp. (Diaspididae)			1					1
Ligyrus villosus burmeister (Scarabaeidae)			5					5
Lithraeus egenus (Blanchard) (Bruchidae)			2					2
Melanaspis sp. (Diaspididae)							1	1
Micrapate scabrata (Erichson) (Bostrichidae)			1					1
Microgryllus pallipes philippi (Gryllidae)			5					5
Microsphaeropsis sp.					1			1
Noctuidae, species of			2					2
Nomophila sp. (Pyralidae)			1					1
Nysius sp. (Lygaeidae)			2					2
Oecophoridae, species of			1			2		3
Palinaspis sp. (Diaspididae)					1			1
Pentatomidae, species of						1		1
Phaeoseptoria sp.					1			1
Phomopsis sp.					1	1		2
Pseudaletia impuncta (Guenee) (Noctuidae)			2					2
Pseudaletia sp. (Noctuidae)			1					1
Pseudaonidia trilobitiformis (green) (Diaspididae)	1			1	5	10	1	18
Pseudococcidae, species of		1	22		1	3	2	30
Pseudococcus sp. (Pseudococcidae)			15					15
Pyraustinae, species of (Crambidae)			1					1
Rhyephenes sp. (Curculionidae)			1					1
Sitona sp. (Curculionidae)			1					1

PEST	BOL	BRA	CHI	COL	ECU	PER	VEN	Total
Sphaceloma perseae Jenkins		9	1		1		1	13
Sphaceloma sp.		1				1		2
Stenoma catenifer Walsingham (Oecophoridae)		3	1	1	19	8	7	39
Tenebrionidae, species of			1					1
Trialeurodes sp. (Aleyrodidae)								1
Total	2	17	109	5	37	31	16	221

BOL – Bolivia, BRA- Brazil, CHI – Chile, COL – Columbia, ECU – Ecuador, PER – Peru, VEN – Venezuela.

Appendix 2

Likelihood of Entry, Introduction, and Establishment of *Potato Spindle Tuber Viroid (PSTVd)* with Imported 'Hass' Avocado (*Persea americana*) Fruit from Peru.

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Executive Summary

In the Peruvian Avocado PRA, the consequences of introduction and likelihood of introduction of PSTVd were analyzed and rated as medium for both measures. In this appendix, we evaluate the likelihood of establishment based on three pathways, commercial fruit disposal, residential disposal, and seed propagation.

Pathways for Establishment

In the PRA it was determined that PSTVd is unlikely to come into contact with hosts. In potato, natural spread of PSTVd is through seed or aphid transmission (CABI, 2004). PSTVd and a related viroid, Avocado Sun blotch Viroid (ASBVd), are known to be transmitted through seed or pollen of infected plants (Desjardins et al., 1984; Fernow et al., 1970). Establishment would require infected seed or fruit tissue to come into contact with a host. We evaluate the likelihood of establishment based on three pathways, commercial fruit disposal, residential disposal, and seed propagation. We did not evaluate the likelihood of an irrigation water pathway but this was considered less likely.

1. Warehouse disposal pathway: To illustrate the fate of exotic organisms on imported fresh produce we used a relevant study. Eight pathways were investigated by Gould *et al.* (2004) in a risk analysis that looked at fresh asparagus infested with lepidopteran eggs. The study examined disposal methods at 14 commercial import warehouses in the U.S. that represented 85% of the asparagus imports from Peru. That report concluded that of the discarded product (not initially sold for consumption): 76.0 % went unbagged into dumpsters; 4.5% went bagged into dumpsters; 11.2% was compacted then placed in landfill; 7.3% went to soup kitchens (consumed); 0.5% was put in the garbage disposal (municipal sewage); 0% went as discounted produce (consumed); 0% was composted; 0% went for animal feed. Dumpsters leading to landfills are a dead-end pathway for insect pests in municipal waste such as, *Anoplophora glabripennis* (Auclair *et al.*, 2005). We assume that the same is true with this pathogen. PSTVd only moves with plant material in the absence of a vector. If all plant material is accounted for in the dumpsters and landfills, the viroid is mitigated if all insect vectors are considered mitigated.

2. Residential disposal pathways: Consumers purchase fruit and take it home from supermarkets. A first discard scenario includes consuming fruit, but discarding stems and calyxes into a garbage disposal and finally into the waste water (sewage) system. In a second discard scenario, stems and calyxes are bagged and put into the trash destined for landfill. In the U.S. over 75% of the population is served by centralized waste water collection and treatment, the remaining population using other on-site systems to treat sewage and waste water (EPA 2004; Zipper, 2003). Waste water (sewage) treatment standards have been developed to reduce populations of pathogens harmful to humans, and this may reduce the viability of PSTVd (EPA, 2004; Zipper, 2003). There are no studies on the quantity of fruits and vegetables discarded in backyard compost in the U. S. One foreign study estimated that up to 0.5% of U. S. apples purchased in Japan ended up as compost (Roberts *et al.*, 1998). Another study estimated that 5% of U. S. cherries purchased in New Zealand ended up as compost (Wearing *et al.*, 2001). If it is assumed that 5% composting mirrors U. S. practices, then it is unlikely that the commodity would be discarded on compost piles. Although no studies have been done, it is assumed that all compost produced by consumers is used on home gardens or yards and not spread directly onto agricultural fields.

3. Seed Propagation pathway: Avocado seeds are frequently propagated in biology classes. Often students are allowed to take their plants home after completion of the class. There is no data available to determine the fate of these plants but some assumptions can be made. Most plants would probably remain indoors and die and be disposed under considerations discussed above. The only possible scenario would be for a propagated tree to be planted outside in proximity to other hosts such as potato or avocado. The avocado tree is relatively frost sensitive and would not survive in most of the United States (Scorza and Wiltbank, 1975). For these reasons, we consider this pathway to be low risk.

Table 1. Likelihood of PSTVd following pathway based on establishment and introduction

Event	**Likelihood**
Consequences of Introduction	High (Risk Assessment Document)
Likelihood of Introduction	High (Risk Assessment Document)
<u>Likelihood of establishment</u>: Warehouse disposal pathway	 Low

Consumer disposal pathway	Low
Propagation pathway	Low
Overall risk of establishment	Low
Overall likelihood of pest following pathway	Low

Conclusions: In the PRA it was determined that there would be a high probability of introduction. This analysis concludes, however, that the probability of establishment is low and, consequently, the overall probability of the pest following the pathway is low.

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